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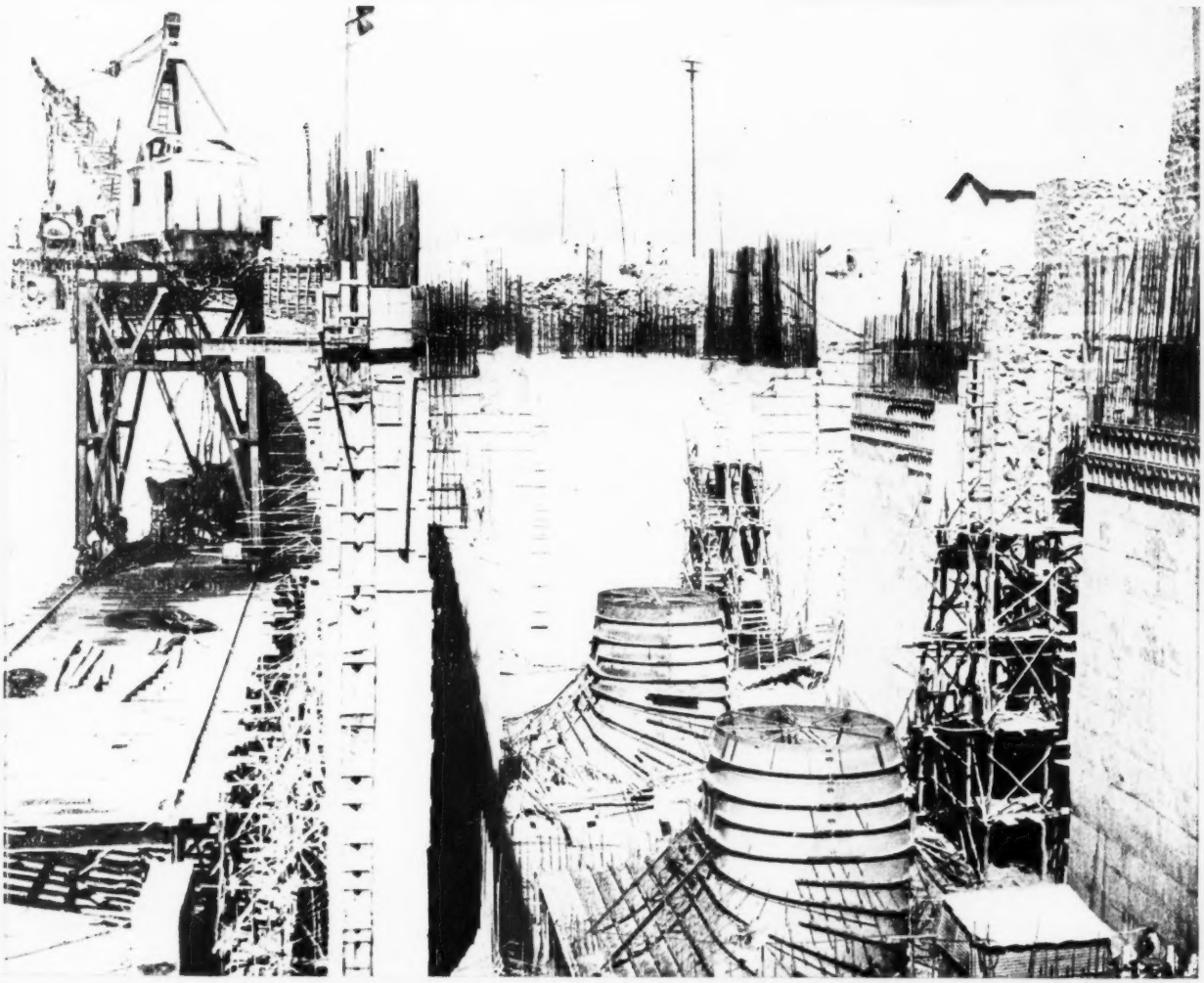

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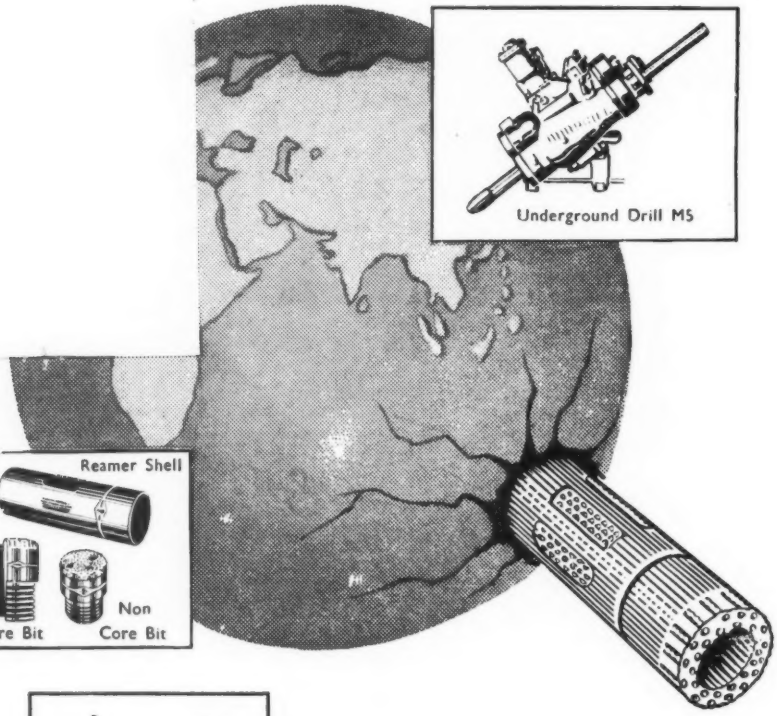

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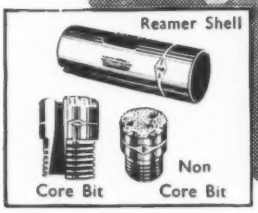

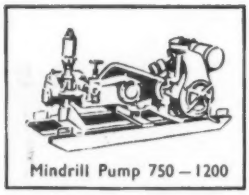
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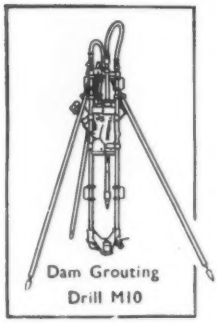
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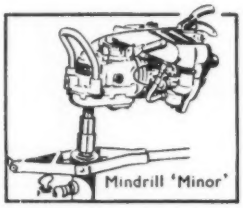
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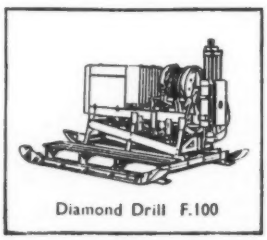
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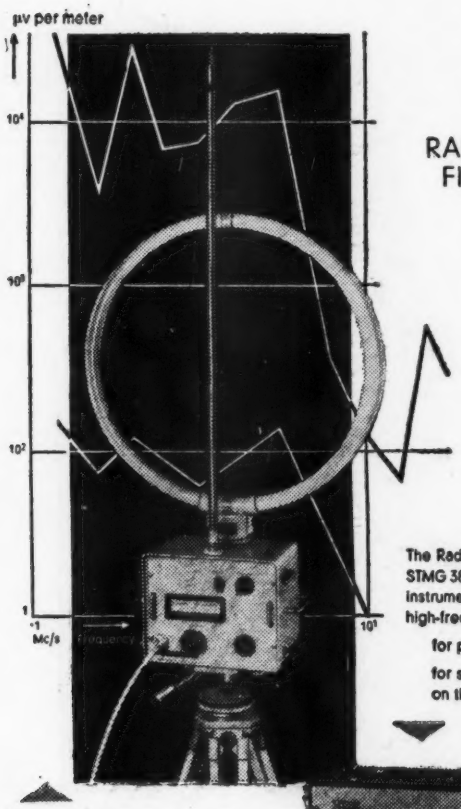

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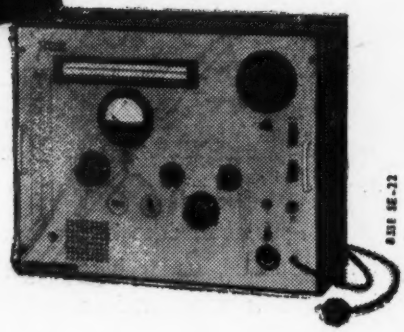

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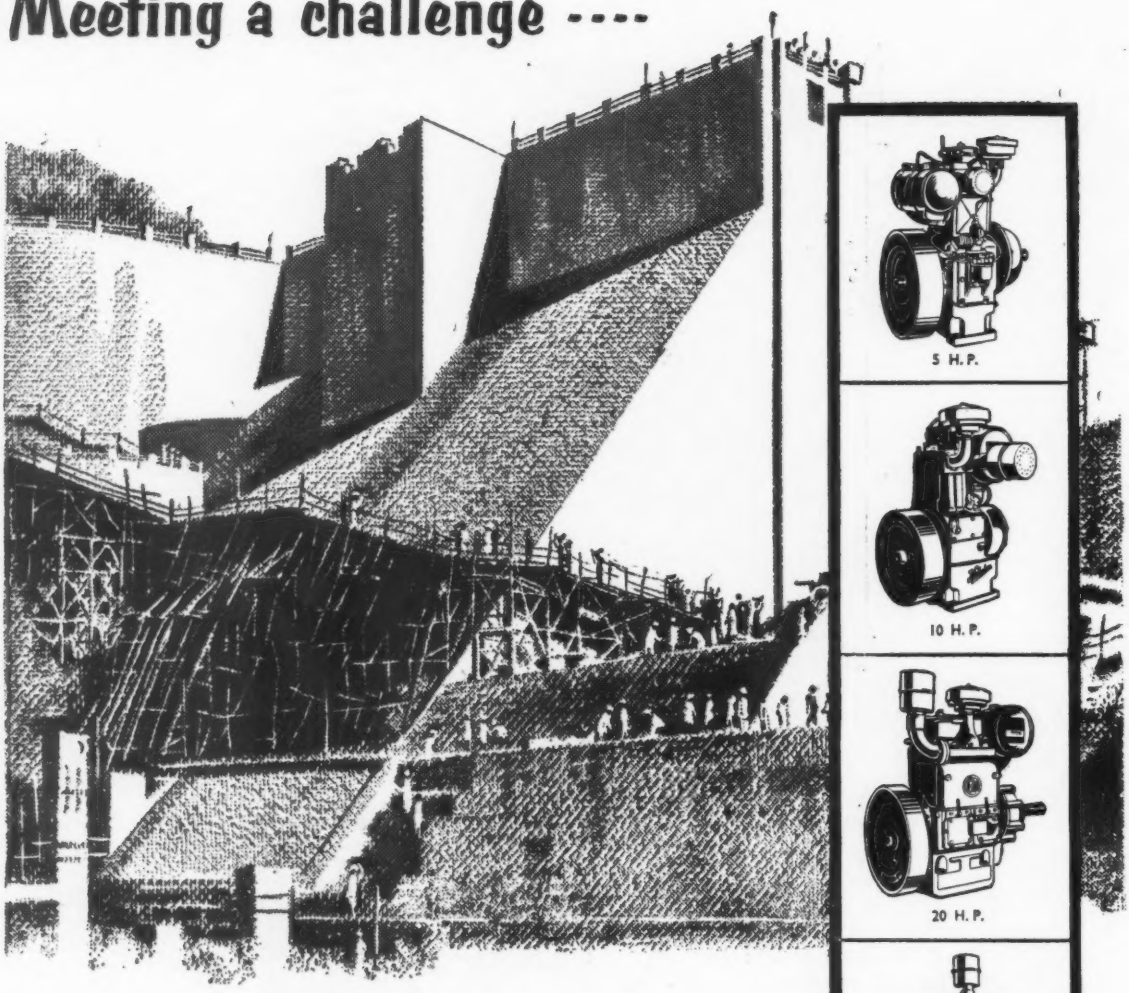

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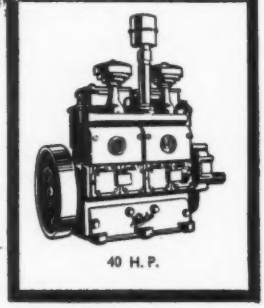
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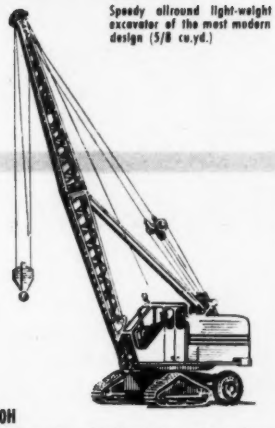

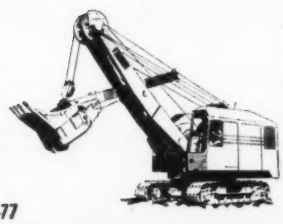

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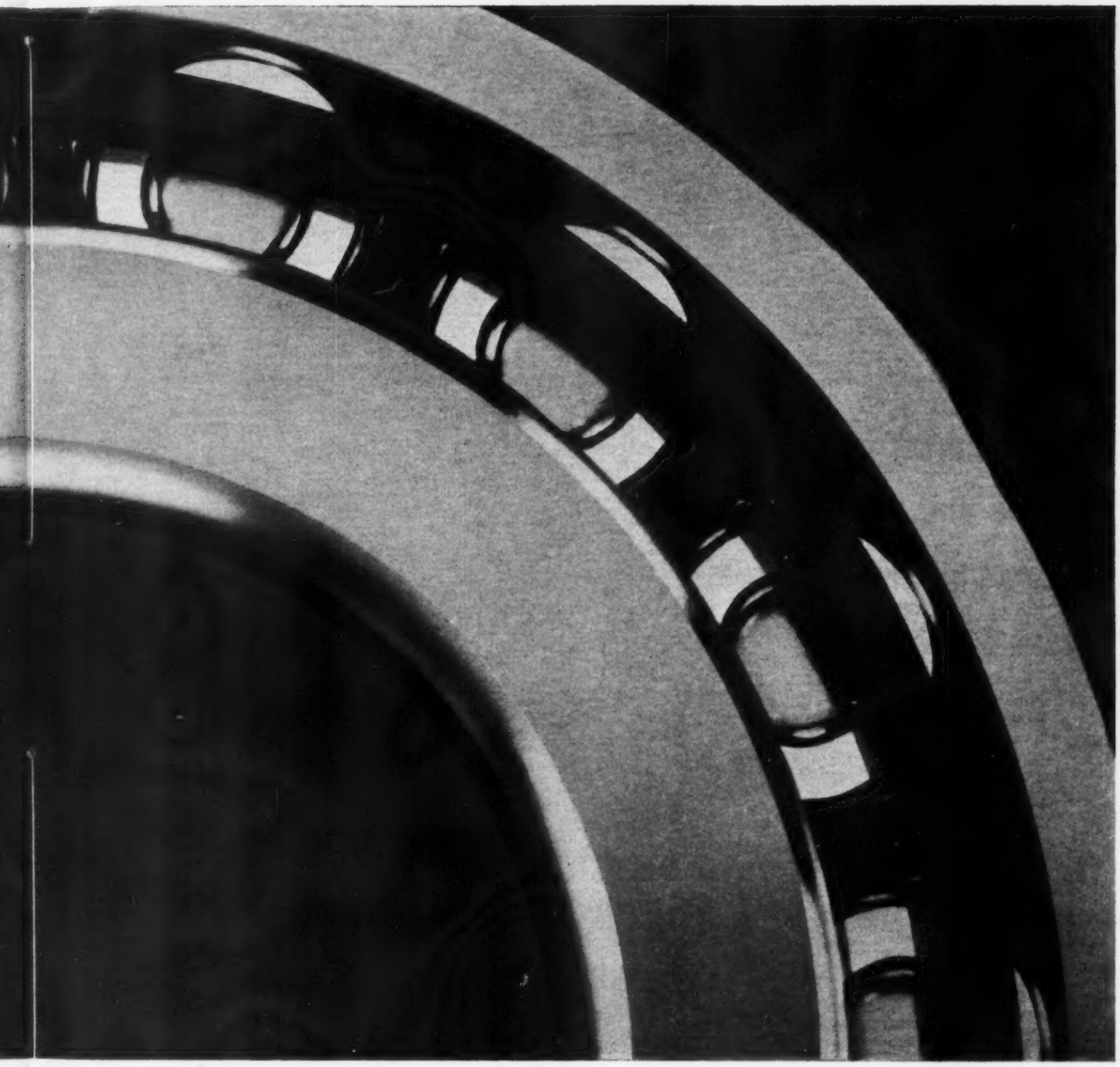

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A familiar sight in the Durgapur of today is this instance of Indo-British collaboration — of Indian and British technicians discussing problems and working together to help build the giant 1 million ton steel plant in the newest steel city of India.

The entire construction work of the Durgapur project has been entrusted to ISCON, a consortium of leading British engineering and electrical firms, and from the very start they are working in partnership, hand in hand, with Indian technicians, Indian workers, skilled and unskilled.

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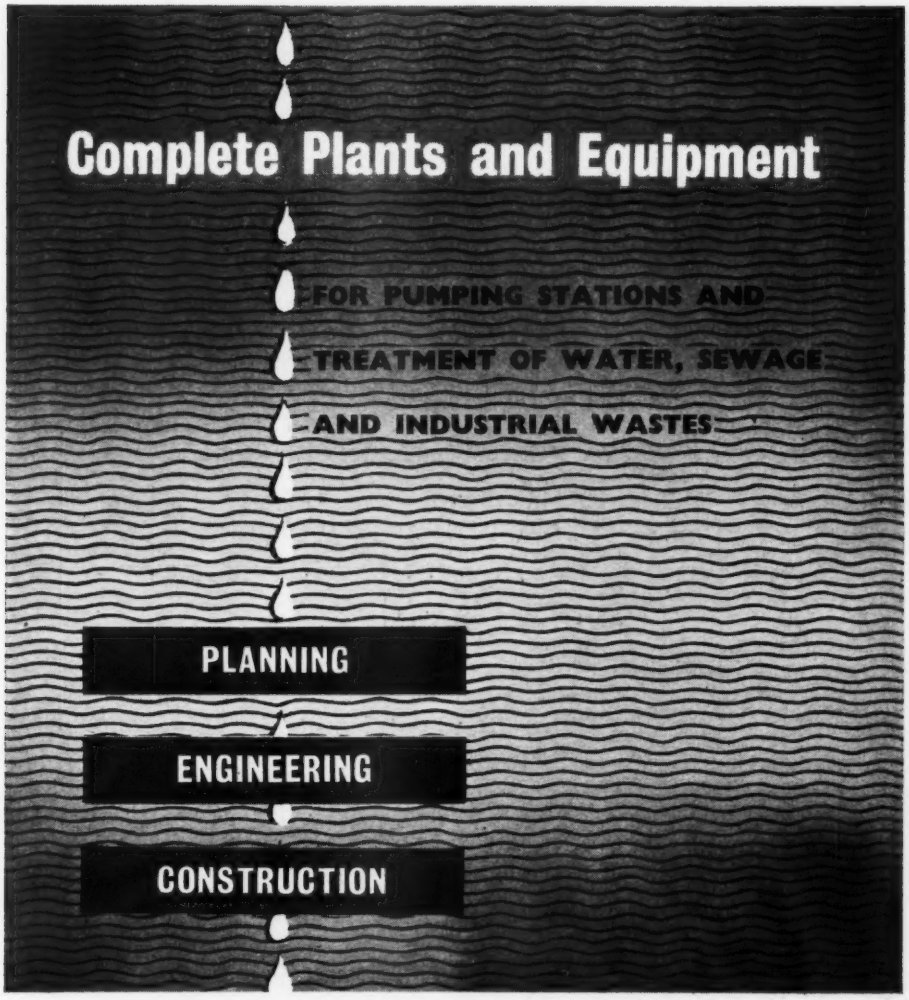

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a mason shows the way

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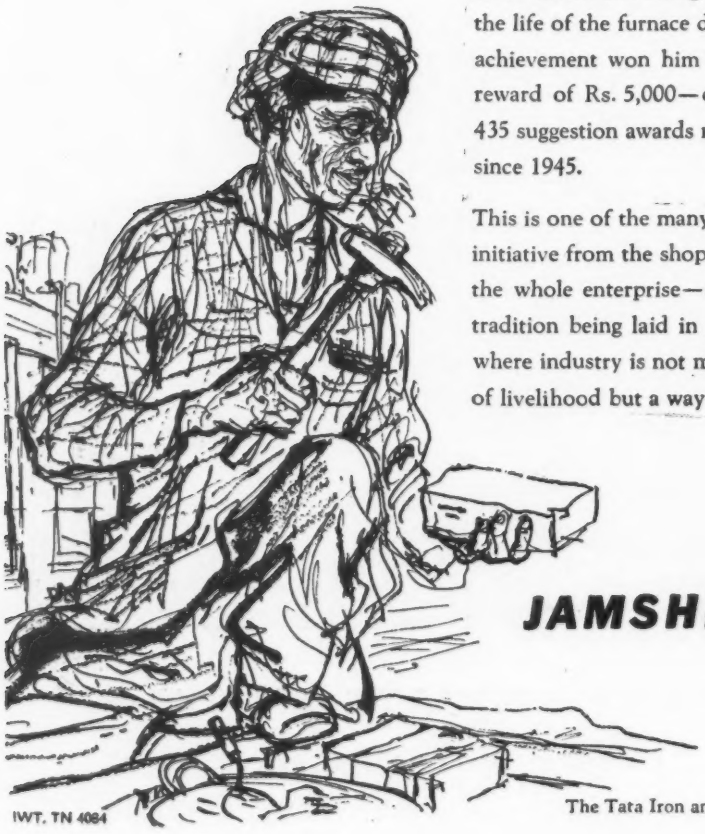
It was left to Zahir Hussain, a 43-year old mason in the Brick Department, to devise a new method of lining which has increased the life of the furnace doors. Zahir Hussain's achievement won him acclaim and a cash reward of Rs. 5,000—one of the 435 suggestion awards made since 1945.

This is one of the many examples of initiative from the shop floor benefiting the whole enterprise—another industrial tradition being laid in Jamshedpur, where industry is not merely a source of livelihood but a way of life.



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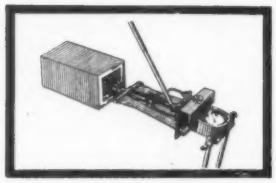

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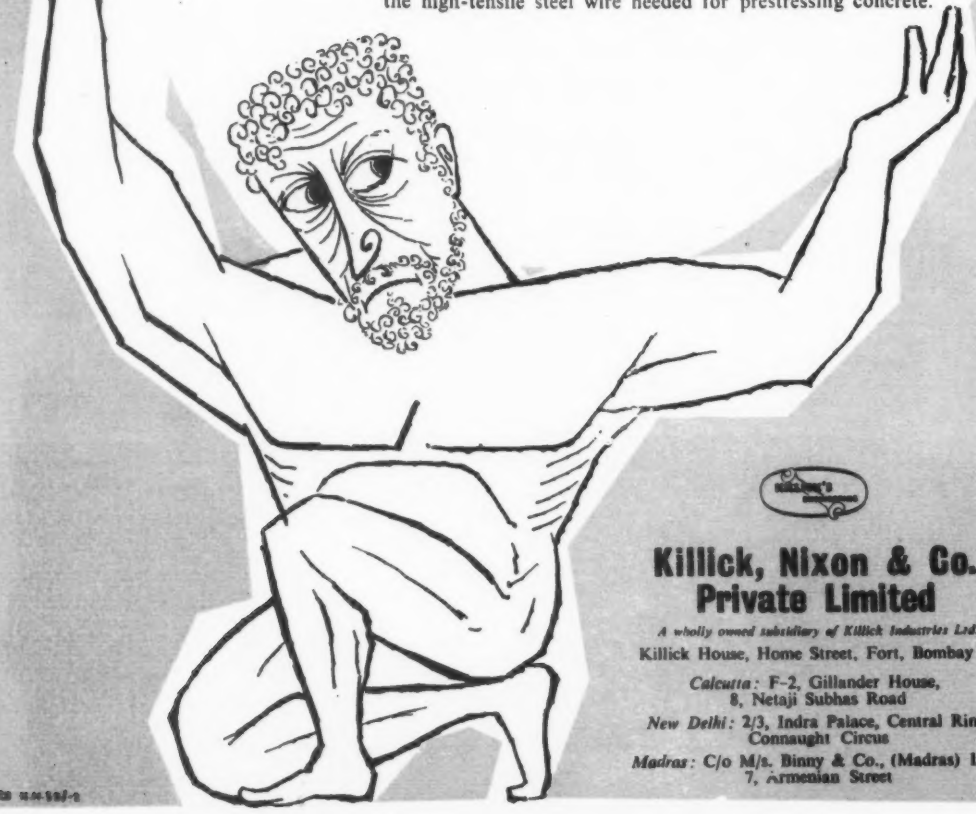

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Editor : K. K. Sinha — P. K. Menon : Mg. Editor

VOL. X — **FEBRUARY 1960** — **NO 2**

CONTENTS

THERMAL POWER STATION AT DURGAPUR	*Dr. B. K. R. Prasad*	1
PACKAGE POWER PLANTS FOR LOW-HEAD HYDRO-ELECTRIC PROJECTS	*R. M. L. Langlois*	2
NUCLEAR POWER STATIONS VERSUS CONVENTIONAL POWER STATIONS	*D. C. Bhardwaj*	7
MODERN STREET-LIGHTING PRACTICE IN THE U. K.	*B. K. Banerjee*	13
HYDRAULIC MODEL AS AN AID IN STUDYING RIVER PROBLEMS	*S. N. Sarkar*	17
DEVELOPMENTS OF FREE-PISTON TURBINE DRIVES IN EUROPE	*Leo Walter*	21
TRENDS IN THE DESIGN OF DAMS AND CONSTRUCTION OF RIVER VALLEY PROJECTS	*V. Rama Rao*	27
TECHNICAL NOTES AND NEWS		31
EDITORIAL		35
OUR CONTRIBUTORS		36

In the comming issue :

Method used for estimating the energy requirements of the future and the reasonable development of power supply *by* J. Klar ; About backwater curves in uniform channels *by* Dr. P. Franke ; Benson boiler *by* L. N. Misra ; Hydraulic turbines-I *by* N. Venkata Row Soil investigation in relation to foundation of hydraulic stuctures *by* Priyatosh Roy ; Water treaty between India and Pakistan ; Symposium on irrigation and drainage at A. S. C. E.

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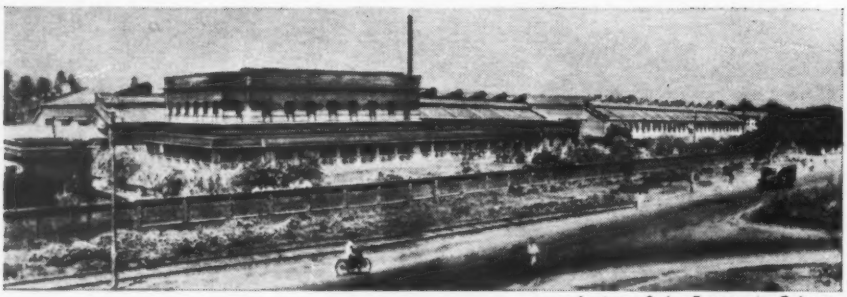

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Thermal Power Station at Durgapur

By Dr. B. K. R. PRASAD

The new thermal power station that is being installed for the Hindustan Steel Works at Durgapur is designed for an ultimate capacity of 350 mW, and will consist of two units of 75 mW each in the first stage and two units of 100 mW each at a later stage. The plant will be of the semi-outdoor type with all modern technical features. The generators will be hydrogen cooled 13.8 kV 50 cycles at 3000 rpm. When hydrogen pressure is increased to 30 psig the output of the units will be 82.5 mW. The maximum mVA rating will be 97 mVA at 15 psig and 103 mVA at 30 psig. The turbines will operate at 1450 psig steam pressure and 1000°F. Power from the first two units will be stepped up by two transformers of 100 mVA, using isolated phase bus system for 13.8 kV. An auxiliary unit of 10 mVA will also be installed.

The sub-station will control the high tension (138kV) power and will later on tie up with the Damodar Valley Corporation system of 220 kV. A 33 kV sub-station with 3-50 mVA transformers will provide power supply to other consumers by means of separate feeders (8) Sectionalising arrangement are provided for the 33 kV and 138 kV buses, with a transfer bus for ensuring continuity of supply.

Two 138 kV feeders will go to Burdwan and two to Kalipahari. Two more will go for inter connection of the West Bengal Government power station with the Damodar Valley grid system. Four feeders of 13.8 kV will supply power to the steel mill at Durgapur. The local 3.3. kV supply system will deliver its suppy from the third winding of the 50 mVA transformers.

The planning of the power station, and the 138 kV and 33 kV sub stations as a single project has resulted in maximum coordination and highest economy. The Durgapur and Damodar Valley power projects form a power grid to augment the hydro power generation of the D.V.C. system during seasonal low flow periods. The Damodar Valley thermal station has already three units of 60 mW at 850 psig and 900°F and a fourth unit of 75 mVA is being added.

The Damodar Valley power grid now extends to Calcutta in the east, Dalmianagar and Patna in the West. The site of Durgapur power plant is ideal from the economic and technical point of view and fits in with the plans of the Government to institute a coal-based heavy industry programme to strengthen the industrial economy and provide employment to a large number of technical personnel.

The Durgapur power station and steel works are situated in the coal belt of West Bengal and within 70 miles of the large iron ore deposits, A navigational canal and an electrical railway system provide very good transport facilities. The coke ovens, by-products plant, gas grid system and tar distillation plants are all located in this area. In the vicinity of the new steel mill of 1,00,000 tons/yr capacity, a plant for the manufacture of heavy machinery and mining equipment will also be located. This group of steel mills, power plant and other industries marks the beginning of an industrial revolution in this area. In addition to the above loads, the Tata Iron and Steel Co. at Jamshedpur, the electrification of the coal mines and railways, and the demand, from the Calcutta Electric Supply Corporation will all contribute to the load demands on the combined grid of the Durgapur and Damodar Valley systems. The boilers of the Durgapur power plant will also supply process steam required by the coke ovens and some local industries.

Fuel economy for the power plant is effected by its location close to the coke ovens and the steel plant and due to its multipurpose aspects. Adequate fuel supply is effected and guaranteed under varying conditions. High ash content non-coking coal (washery middlings from the steel plant) which is uneconomical for other purposes, but is suitable for the boiler plant is being used for the purpose of power generation. Proximity of the fuel source to the steel plant facilitates transport by conveyor belts. Coke oven gas will also be used for fuel to the boilers.

About 1000 tons/day of fuel supply are handled by the conveyor belts, and an equal amount by rail cars and car tipplers. About 200 tons coal/hr are normally supplied to the coal bunkers. Gas supply from the steel is piped to the power plant and forms the basic fuel. Oil fuel is also provided for emergencies. The operation of the boiler for use of pulverised coal, coke oven gas and heavy oil is automatic simultaneously or independently.

Boiler feed water is demineralised water from the river, and make up water is also derived from the same source as it is more economical than evaporation by extraction steam. The water treatment plant is adequate for future extensions. Cooling water is derived from the Damodar river, about 35,000 gallons/minute and flows by gravity from the reservoir. The discharge water goes back into the reservoir after being cooled off in the return pipes.

The boiler ash handling plant is automatic complete with preheaters, dust collectors and electro static precipitators, and is operated pneumatically. The bottom ash is handled wet and is pumped to the disposal area. Each boiler has a smoke stack of 14 ft. dia and 235 ft. high.

[*Continued on page* 25

Package Power Plants for Low-Head Hydro-electric Projects

By R. M. L. LANGLOIS

In low-head hydro-electric projects, the cost of the power units and that of the construction of the power-house in relation to installed capacity is relatively high and rises proportionately with the decrease in head. Profitable exploitation of low heads therefore poses problems difficult to solve and becomes impossible below a certain height of the head.

Following the way opened by the Roestin project in Germany in 1936 and by the Castet project of the French National Railways in 1950, Electricite de France has been actively cooperating with manufacturers of hydroelectric power equipment in the design and experimentation of a special type of power unit, the "package power plant". The National Electric Power Company has succeeded in considerably extending the field of utilization of the latter in regard to height of head and output and was the first to put large-size units of relatively high output into operation.

These units consist of an axial-flow turbine of the propeller type which drives an electric generator located inside a sealed housing in the shape of a bulb and placed in the flume. Different solutions are possible for the turbine, in particular for the manner of regulation. The simplest design has fixed propeller blades and guides. The bulb may be of the upstream or downstream type, depending on the respective location of the generator. Regardless of the different types of the package power plants, they all have the following essential characteristics:

Axial flow from flume throat to draft tube and consequent elimination of the spiral setting and the guide-case of the standard units with attendant reduction of width and height;

installation of the generator within the water channels and consequent elimination of the power-house and the incidental possibility of simplifying generator cooling;

compact construction making possible monobloc units, except for very large assemblies, that can be installed easily and rapidly.

All other factors being equal, these characteristics in themselves result in reduced costs per unit of installed capacity.

Field of Utilization of Package Power Plants

The great variety in the construction of the units and in the layout of the projects, made possible by the package power plants in individual cases, opens a wide field in regard to capacity and height of head which may be divided in three main sectors as follows:

Very low-head (16ft. and less) and low-flow installations called "pocket power projects.

Low-head (16 to 65 ft.) and medium-flow installations;

Low-head and relatively high-flow installations.

Low-Head/Low-Flow Installations

Pocket power projects are very low-head and low-flow installations for automatic operation without supervision and require only a minimum of maintenance. They are designed to furnish extra power at grid voltage and frequency in a grid which is capable of making up the loss if they drop out through water shortage or other causes.

Their operation is quite different from that of the many small plants installed for supplying localized needs during the last fifty years. The latter had to be designed and equipped to provide against the risk of failure and to operate within an acceptable range of voltage and frequency.

Although the requirements for their operation are not very severe, the equipment of such pocket power projects still poses problems of cost that are difficult to solve because this cost, expressed per unit of capacity and including not only the price of the units but also that of the civil engineering work and the switch gear, increases rapidly with the decrease in head. Power output of a low-head project is further affected by the decrease in head which accompanies floods and this drop also increases with the decrease in head. Therefore, in order to make sure of the profitability of a project of this type, the units must be designed to continue operation when the head decreases or for a smaller than the average volume of flow of the river which results in a relative increase of the fixed or semi-fixed costs.

Under these conditions, it will be easily seen that there exists a minimum limit of head—synonymous with a minimum limit of profitability—below which a pocket power project of even the simplest type ceases to be profitable. This limit of profitability is dependent upon a number of factors which include, among others, the cost of construction and the price of the power; the annual mean flow of the river; and the topography of the site which affects construction costs, power output and connection into the network.

Under present conditions in France, a project for a head of 6-1/2 feet practically does not seem profitable

except in the rare cases where local circumstances are exceptionally favorable. All things being equal, given conditions become more favorable when it is possible to plan on several flumes with similar characteristics. In that case, the cost per unit of installed capacity may decrease appreciably both because generator units produced in series are less expensive and because methods and equipment for civil engineering work can be employed that will reduce the cost of the latter but whose use would not be feasible for a single-unit pocket power project.

The solution of the problem of costs in the construction of pocket power projects has now been made easier and, strictly speaking, possible by the development of package power plants. The inherent design of the latter permits operation without supervision, requires a minimum of maintenance, and does not necessitate extensive civil engineering work. Their compact construction makes it possible to ship them to location factory-assembled, ready for installation, and their price per kW, all given factors being the same, is relatively low. These basic features lend themselves to a variety of solutions under given circumstances of which the main ones are detailed below.

When the project is close to the limit of profitability and an overflow weir exists at a lock, recourse may be had to one or more package power plants, having a propeller turbine with fixed blades and guides operating at a reasonably high efficiency and directly driving an asynchronous generator located in a metal syphon and the flume also being of metal. Such a unit has an all-or-nothing constant output. Stopping or starting is controlled in relation to the upstream level through the priming or unpriming of the syphon. Priming is effected through a vacuum pump or a suction fan and unpriming by the opening of a gate. Civil engineering work consists merely of the foundations for the unit and only a limited amount of switchgear is required.

However, this solution has the disadvantage of producing power only in "spurts" when the flow of the river is less than the design flow of the turbine and leads to "water wastage" when the unit is stopped and the river flow cannot be impounded.

When the head lies appreciably above the limit of profitability, it may be advantageous in certain cases to provide a more elaborate installation in order to eliminate the all-or-nothing operation. This may be done by using underpressure turbines with adjustable blades in which the blade angle is controlled in relation to the upstream level. The unit is more expensive but has greater hydraulic efficiency and greater reliability in operation.

When the design factors are adequate, i. e. when the dimensions and speed of the unit make this practicable, it will be advantageous to replace the asynchronous by a synchronous generator designed for asynchronous starting.

In all these cases, the switchgear equipment for these pocket power projects is quite simple but provision should be made that these auxiliary plants which are to furnish extra power to a grid, do not become a hindrance in the operation of the latter or overload its protective devices.

Low-Head/Medium-Flow Installations

The satisfactory operation of prototypes of these package power plants installed in pocket power projects, coupled with their characteristics of simplicity, robustness and ease of maintenance have led to the thought that the utilization of such units would constitute a happy solution to the problem of exploiting relatively higher heads in rivers with a low volume of flow. Investigation of this has tended to show that it is economically practical to use package power plants for heads from 40 to 65 feet and a flow of some thousand cubic feet per second for which standard types of equipment would be too expensive.

This type of installation is particularly advantageous when it is provided in a certain number of consecutive locks by units with identical specifications. As an experiment, it was decided to equip the hydroelectric project of the Basse-Maulde with 5 separate power plants consisting of a total of 24 identical units with a capacity of 800 kW under a head of 45.9 feet.

Low-Head/High-Flow Installations

Starting at heads of 26 to 30 feet in rivers with a large flow, the construction of power plants with standard vertical units is entirely feasible. The latter are almost necessarily of large dimensions by reason of the width required. Small in number therefore, at least in France, they must be equipped with double flow regulation so as to retain an acceptable output under variations of flow volume.

It would appear that, subsequent to investigations made in connection with the tidal power project of the Rance, the idea was adopted of utilizing large-size package power plants with double regulation for low-head river projects because such units had been shown to be particularly advantageous under the special operating conditions of the tidal power project.

In doing so, certain savings in first costs may be counted on, particularly in regard to civil engineering work, which will result in a lower limit of profitability for this type of installation. However, it will still be necessary to keep down the operating costs of such a project and eliminate the risk of loss in power production due to prolonged stoppage of the units for repairs caused by defects in or damage to them. Here lies the main difficulty with them because access even to large components and parts is not easy in these units.

In spite of this, Electricite de France believed that an experimental installation would be justificable and is now equipping the Beaumont-Monteux project on the Isere River with package power plant, designed for a flow of 3, 530 cusec under a head of 32.8 ft.

Independent Power Production

The simplified package power plants, designed to furnish extra power to a grid, are as such not capable

of being used as independent power producers. However, provided that they have a synchronous generator, they can be equipped with a special device which makes this possible. This device is an electric arrangement sensitive to variations in frequency which varies an additional load connected to the terminals of the alternator. In that case and when the flow is adequate, the unit operates permanently under the full output corresponding to the available head, regardless of the exterior load.

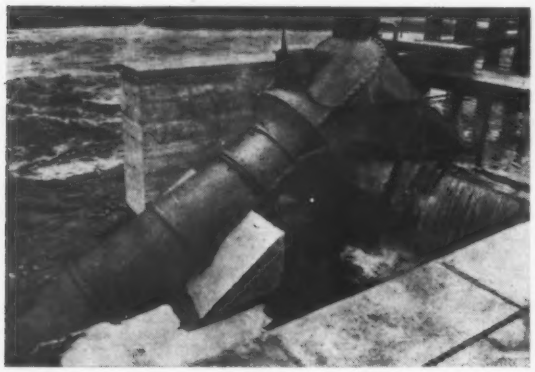
Such an assembly is definitely more expensive than one of the normal package power plants. It retains, however, their robust characteristics (the regulation system can be entirely static), their small dimensions and relative light weight. Its use would seem to be of advantage for projects in isolated regions not easily accessible, and would produce power at a cost lower than that of small local thermal power plants.

Examples of Actual Installations

The first package power plants in France were installed at the Castet plant of the French National Railways in 1953 and consisted of two "Neyrpic-Alsthom" units with the following characteristics:

head.....	24.6 ft	delivered capacity...	810 kW
flow.....	341.4 cusec	tension.....	500 V
speed.....	254 rpm		

Since then a certain number of projects have been equipped with such units by Electricite de France and the details of such installations are given below.



54-kW Package Power Plant of the "La Maignannerie" Pocket Power Project on the Mayenne River

POCKET POWER PROJECT "LA MAIGNANNERIE"

This project is located on the Mayenne River and consists of an upstream package plant and syphon. The "Neyrpic" turbine with fixed blades and gides directly drives an "Alsthom" asynchronous generator operating in oil and has the following characteristics:

head.....	6.4 ft	delivered capacity.	54 kW
flow.....	158.9 cusec	tension.....	380 V
speed.....	225 rpm		

The automatic all-or-nothing operation is controlled by the pondage level.

POCKET POWER PROJECT "SAINT-JORY"

This project is located on the by-pass canal of the Garonne River and utilizes the head created by a canal lock which has a year-round constant flow volume. The equipment consists of a submerged vertical unit and syphon in which the high point of the syphon coincides with the bend of the flume. The "S. F. A. C." turbine with fixed blades and guides directly drives a "S. W." asynchronous generator operating in air and had the following characteristics:

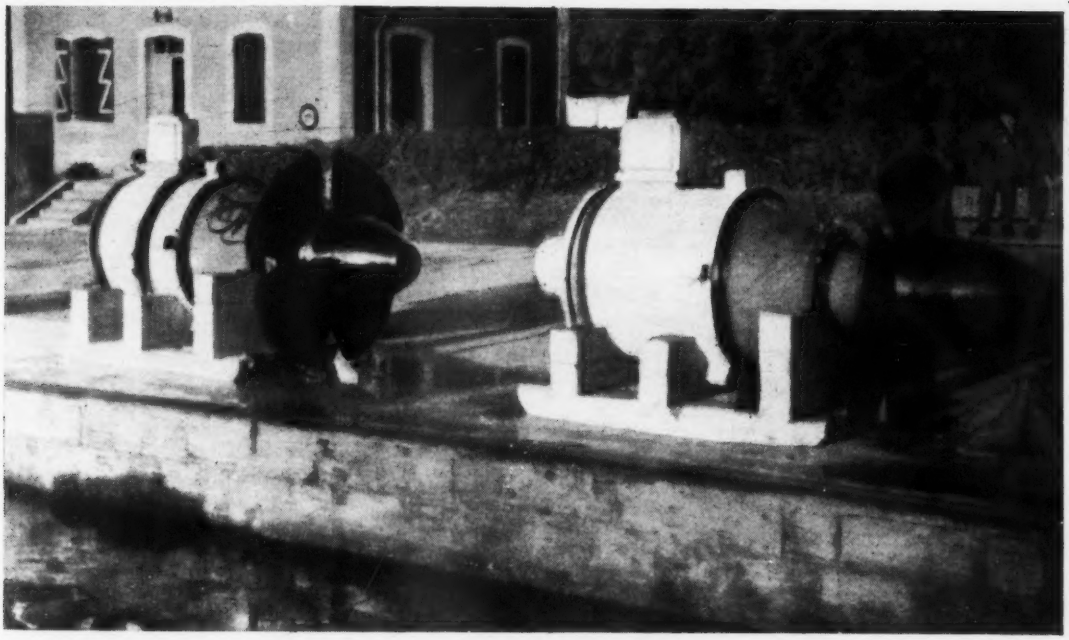
head.....	8.6	delivered capacity..	120 kW
flow.....	211.8 cusec	tension.....	380 V
speed.....	214 rpm		

The unit operates permanently under full output. A special device for partial utilization of the syphon makes it possible (which is absolutely necessary) not to modify the flow of water if the unit is disconnected.

Upstream view of the "Saint-Jory" Pocket Power Project on the Bypass Canal of the Garonne River

POCKET POWER PROJECT "VERDUN"

This project is located on the Meuse River and utilizes the head created by an existing weir and by-pass structures. It is equipped with two submerged upstream package plants, each equipped with one "Neyrpic" turbine with mobile blades and fixed guides, directly



202-kW Package Power Plant at the "Verdun" Pocket Power Project on the Meuse River

driving an "Alsthom" asynchronous generator operating in oil, and has the following characteristics.

head..... 10.3 ft delivered capacity.... 202 kW
flow..... 353.1 cusec tension..... 380 V
speed..... 181 rpm

Operation is automatic with the propeller blade angle controlled by the pondage level.

"LARTIGE" POWER PROJECT

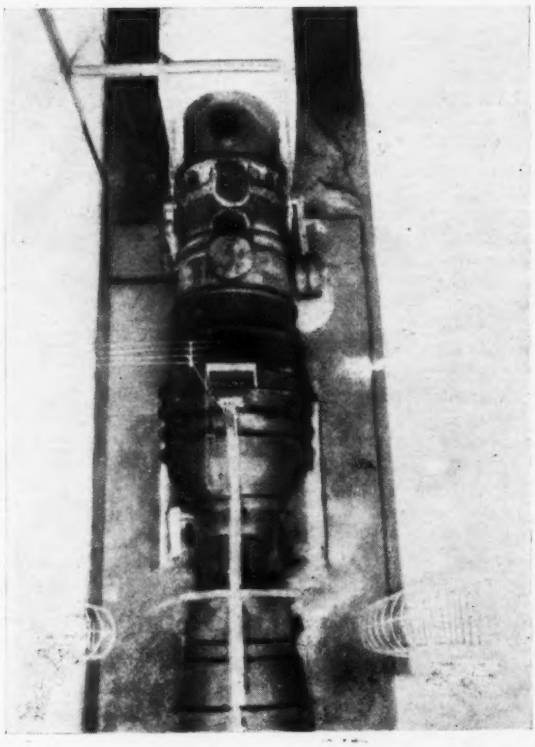
This project is equipped with 3 package plants and casing, consisting of a turbine with fixed blades and guides and an asynchronous generator. One of the units was built by "Jeumont" and the turbines and generators of the other two were constructed respectively by "Coulut & Borne" and by "Breguet". The units have the following characteristics:

head..... 53.1 ft delivered capacity...14.200 kW
flow.....3,531 cusec tension.....5,650 V
speed..... 150 rpm

"CAMBEYRAC" POWER PROJECT

This project on the Truyere River is equipped with two downstream package plants for double regulation with synchronous generators operating in air and designed for use as turbine or pump in the respective directions of flow as an experiment on operation in tidal power plants. The units have the following characteristics:

817-kW Package Power Plant at the "Lartige" Hydroelectric Project on the Maulde River



head..... 35.2 ft delivered capacity. 5,000kW
flow..... 1,943.3 cusec tension..... 3,300 V
speed.....150 & 136.4 rpm

The installation is operated by remote control from the "Lardit" power project at a distance of about 6/10 of a mile.

"Beaumont-Monteux" Power Project

A downstream package plant is being installed at the emplacement on the Isere River provided for a lock during construction of the Beaumont-Monteux Power Station in 1920. The unit consists of a "Neyrpic" turbine with mobile blades and guides, directly driving an "Alsthom" synchronous generator operating in air and has the following characteristics:

head..... 36.0 ft delivered capacity..8,500 kW
flow..... 236.6 cusec tension..... 5,650 V
speed..... 15 rpm.

Conclusion

The technical problem of the utilization of package power plants, both on pocket power projects as well as in larger installations, seems to have been solved. However, most of the installations are still only prototypes and constructed too recently as that it would be possible to draw any definite conclusions on operational profitability. The solutions presently being investigated also are based on a great variety of arrangements and need to be evolved further by continuing the construction of prototypes in order to define the limits of head and flow rates for the profitable utilization of these package power plants.

[*Continued from page* 12

Nuclear Power Stations Versus Conventional Power Stations

spinning wheel and subsidise hand-loom, even though yarn and cloth can be produced much cheaper by mills.

There is a feeling in the minds of some people that if we do not instal nuclear stations now, we may be left behind in the technological development in this direction. This is not correct, because at present we have to import almost all the machinery required for these stations and the only technical experience we shall gain is the operation of the plant. What we need most is the experience to design and build these stations, for which we must first develop our non-existent industries for the manufacture of boilers, turbines, generators, switchgear, instruments etc. Our experience of operating thermal stations has not helped us to develop these industries. We require finance and machinery for the same and the latter needs foreign exchange. It will, therefore, be wise if for the next few years we put off the nuclear power programme and utilise our limited resources on the development of these industries, which will enable us to build nuclear power stations when we actually need them. The foreign exchange spent on these industries will save us foreign exchange in future. But the extra foreign exchange required for the nuclear stations at this time will not save us any foreign exchange in future.

One point raised against the conventional power stations is that this necessitates extra capital investment in the development of mines and railways. This is true. But we are now able to develop these industries without spending any significant foreign exchange. We are nearing self sufficiency in the production of railway track material and rolling stock and will be self sufficient in mining machinery within the next few years. The extra expenditure on these developments would give employment to lot more persons than the extra expenditure incurred on nuclear stations.

One argument for installing the nuclear stations at this time is to produce plutonium for use in the fast or thermal breeder reactors to be installed after 1966. The reactors using plutonium have yet to prove their commercial success. Commercial reactors of this type may not be available before 1970. By that time plenty of plutonium would be available at reasonable prices from abroad as the urgency for these breeder reactors elsewhere has receded owing to discovery of large reserves of Uranium.

Conclusions

As there is no shortage of conventional resources for power generation in India at present, the authorities concerned with the development of power in the country should give very careful consideration to the merits of nuclear and conventional power stations. In this connection the following remarks of Professor Francis Perrin, President of the Second International Conference on the Peaceful Uses of Atomic Energy held at Geneva in October last, have significant meaning for us:—

"Under-developed countries could not, it would seem, profit from the opportunities offered by atomic energy until they had gone through a preliminary stage of industrialisation in the old way. If such a country had traditional power resources it would do better to try to make use of them as the difficulties it must overcome would be even greater with atomic energy".

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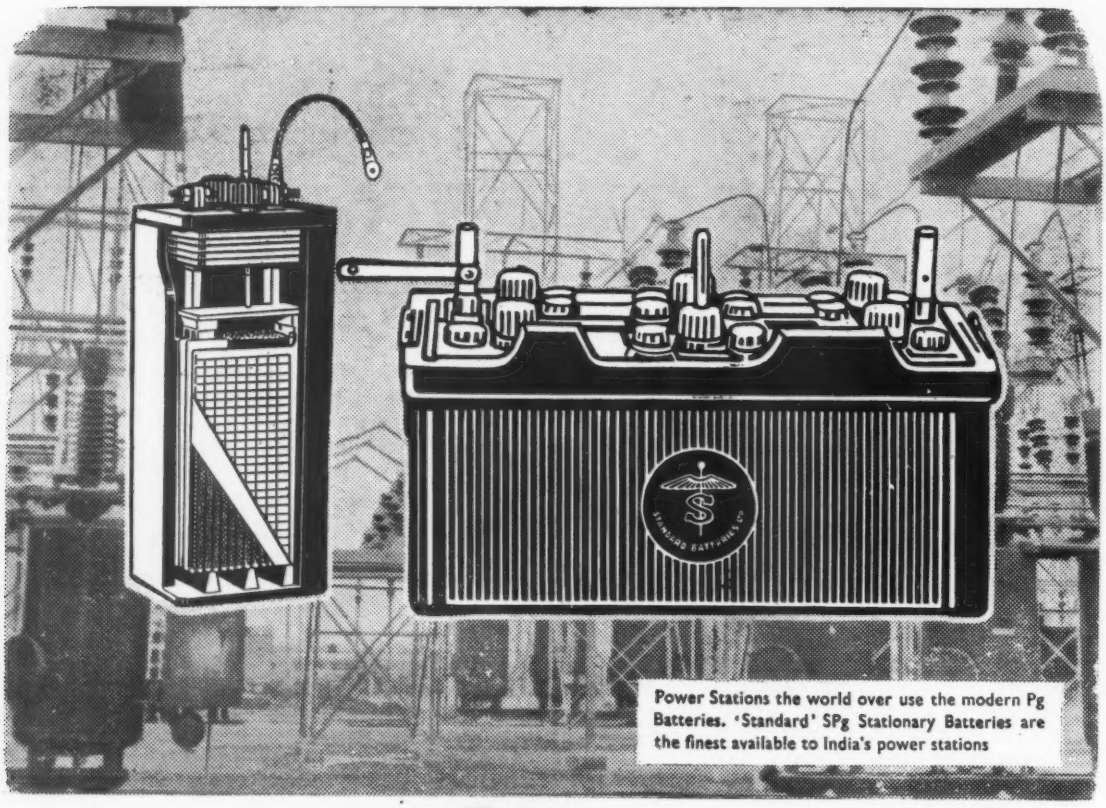

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Nuclear Power Stations Versus Conventional Power Stations

By D. C. BHARDWAJ

Living standard is related to per capita energy consumption. Higher energy consumption per head means higher living standard. An average man in an advanced country in these days enjoys a living standard far more luxurious than that enjoyed by the kings of the ancient times. This is due to the availability of abundant energy derived from fossil fuels and hydro power. The total energy consumed in any country can be judged from the quantity of electricity consumed in that country, as the two bear a certain ratio which is 6 to 12 times. Per capita electricity consumption and national income in some of the countries is given in table I.

Table I.

Country	*Per capita electricity consumption in 1957 kWh*	*Per capita national income in 1952 U.S. dollars*
Norway.	6,752	714
Canada.	5,519	1,284
U. S. A.	4,069	1,857
Sweden.	3,747	914
United Kingdom	1,871	715
Australia.	1,860	912
W. Germany.	1,675	461
Union of South Africa.	1,209	270
U. S. S. R.	959	-
Japan.	801	165
Israel.	700	-
Turkey	50	168
India.	27	57
China.	25	-
Pakistan.	10	-

Consumption of energy is continuously increasing everywhere owing to the increase in population as well as due to improvement in living standards. There is no sign yet of saturation limit reaching in respect of per capita energy consumption even in the most advanced countries. During the last few decades electricity consumption in the industrialised countries has been doubling every 8-10 years. In India the total installed power capacity is to be doubled in the current Five Year Plan and is then again to be doubled in 6 years. If we assume average 10 years' doubling period for energy consumption for the whole world, and if this tendency continues unabated, total energy consumption of the world after 50 years will be about 30 times and after 100 years about 1,000 times the present rate of consumption. Approximate total and per capita energy reserves of fossil fuels and hydro power for some countries of the world are given in table II.

World's energy reserves of fossil fuels can last for several centuries at the present rate of consumption, but when we consider the rate at which the consumption is increasing, these reserves may not last for more than a century. Even the hydro-power which has been so far developed only about 7% of the total patential, will be all fully utilised in about 30 years if all the future requirement of electric power is met by this source alone.

In India our coal and lignite reserves of 45,000 million tonnes should last for 1,000 years at the present rate of consumption of 45 million tonnes per year. But if the living standard of our people were to rise

Table II

	Absolute energy reserves in trillions of kWh electricity equivalent					*Per capita reserves in millions of kWh*
	Coal	*Lignite*	*Petroluem*	*Natural gas*	*Water power*	
India.	499,416	7,083	77	-	200	1,899
Pakistan.	-	410	35	1	4	59
China.	2,472,000	41	41	-	685	5,429
United States.	10,619,728	1,208,125	46,922	63,454	224	77,085
U. S. S. R.	9,920,000	527,732	16,284	10,261	464	53,358
United Kingdom	1,368,000	1,200	6	-	9	27,093
West Germany	1,792,000	157,500	593	-	16	38,400

Based on full calorific value Population as in 1953

to the present day standard of the people in the United States, these reserves would last only a few decades. Even our hydro-power reserves of which we have so far utilised only about 5%, will be fully utilised in about 40 years if all our future requirements of electric power were met from this source alone.

Furthermore, as the utilisation of coal increases beyond a certain fraction of the total reserves, its mining becomes expensive. For instance, in the United Kingdom where the coal reserves should last for more than 200 years at the present rate of consumption, the coal costs are high and its supply fom the mines has been short of the demand by the industry during the last few years and U. K. had to import some fuel from outside. Similarly as the hydro power is developed, the economical schemes are utilised first and the remaining schemes become less and less economical.

The above facts have compelled the world to look for an alternative source of energy and very luckily this has been found in the form of nuclear energy. The total energy reserves of the world in the form of Uranium and Thorium, the two nuclear fuels, are many times those of the fossil fuels. In regard to India, Dr. Bhabha has estimated that the energy reserves of our Uranium and Thorium deposits are equal to 30 times those of coal and lignite. Therefore, nuclear energy is going to play an important part in maintaining the improvement in the living standards of the people in the future.

When the efforts to produce controlled energy from the fusion of lighter atoms are successful, the question of energy reserves will have been solved once for all, because unlimited quantity of heavy hydrogen is available in the water of the oceans of the world.

Description of Nuclear Power Stations

In a nuclear station heat is produced by the fission of Uranium 235 in a nuclear reactor. This heat is extracted from the reactor by means of a suitable coolant which may be a gas or a liquid. The coolant is circulated through the reactor and is then passed through a heat exchanger where it transfers its heat to produce steam. This steam drives a steam turbine and is condensed in a condenser and the condensate is fed back to the heat exchanger. The generator, transformer and switchgear are just the same as in a conventional power station. The main difference, therefore, between a nuclear and a thermal station is the replacement of the boiler plant by a reactor and a heat exchanger, the reactor serving the purpose of boiler furnace.

The heat exchanger, though an expensive equipment, is simple in operation and does not need description. The reactor, however, needs special comments, as there are many possible types of reactors and it is very expensive to design and build these. It is estimated that it requires at least 1000 man-years of professional research and development to reach a prototype stage of a new type of reactor after basic research has been completed. There is so far no ideal type of reactor for power station work. The choice of design depends on the particular conditions of the country. There are six or seven types of reactors being used or developed for power station duty. Brief description of their salient features will not be out of place here.

Gas Cooled Graphite Moderated Reactor:—It utilizes natural Uranium clad in magnox cans as fuel. Carbon dioxide at a pressure of 100-200 psi is used as coolant. The temperature of the gas leaving the reactor is kept below 400°C so as not to damage the fuel elements. This allows steam generation at a maximum pressure of 600 psi and 700°F giving an overall efficiency of 26-28%. The size of this reactor is very bulky and, therefore, its initial cost is high. It is economical only in very large sizes and is used for land based power stations only. Its running fuel costs are low. It is inherently safe for which reason no containment dome is necessary except the pressure vessel of the reactor itself.

Pressurised Water Reactor:—Ordinary water is used as moderator and coolant in this reactor. The water is maintained at a pressure of about 2000/2500 psi and its temperature is kept below the boiling point. The water is passed through a heat exchanger where steam is produced at a pressure of about 800/1500 psi and at a temperature of about 450°/500°F. The plant efficiency with this reactor, therefore, is also poor, unless oil fired superheaters are employed. As ordinary water is not a very good moderator, slightly enriched fuel has to be used and same is enclosed in, zirconium cans to stand the corrosive action of the water. The cost of initial fuel charge and the running fuel costs are, therefore, high. Owing to better cooling capacity of water than gas, the size of the reactor is very compact and its initial cost is lower than that of the gas cooled reactor. The pressure vessel of the reactor is made of very thick plate of stainless steel. In addition a containment dome is provided to prevent the escape of the radioactive steam into the atmosphere in the event of failure of the pressure vessel.

Boiling Water Reactor:—It is a variant of the pressurised water reactor in that the steam is allowed to boil in the reactor and, therefore, lower pressure of about 1000/1500 psi is employed. This affects considerable economy in the cost of the pressure vessel. Moreover, the steam produced in the reactor is directly used in the turbine thereby eliminating the expensive heat exchanger. The steam, however, being slightly radioactive necessitates very special type of seals for the turbine glands and also introduces maintenance problem on the turbine. A serious draw-back of this reactor was its instability, which however has been overcome by using dual cycle. The initial cost of this reactor is expected to be very competitive. The reactor requires a protective steel dome in addition to its pressure vessel.

Sodium Graphite Reactor:—In this reactor liquid sodium is used as the cooling medium. As sodium remains liquid at high temperatures at ordinary pressure, the cost of the pressure vessel is considerably reduced and steam can be obtained at a high pressure and temperature. Sodium however, becomes highly radioactive

and, therefore, double heat exchanger is necessary, the secondary cooling medium being also liquid sodium. Sodium is a costly metal and has to be of high purity. The heat exchangers have to be of very reliable construction to prevent leakage as sodium attacks both water and oxygen. Sodium also attacks graphite, which has therefore to be placed in cans.

Fast Breeder Reactor:—This reactor does not require any moderator, but requires highly enriched fuel to maintain chain reaction with fast neutrons. The fuel is surrounded by a fertile material, which is either natural Uranium or Thorium. The fertile material absorbs the fast moving neutrons escaping from the core and is converted into fissile material. Uranium 238 becomes Plutonium 239 and Thorium 232 becomes Uranium 233. Such breeding of fuel actually takes place even in the thermal reactors using natural or slightly enriched Uranium, but the conversion factor in these reactors is less than unity. In a fast breeder reactor more fuel can be produced than is consumed. It is only with this type of reactor that the entire reserves of Uranium 238 and Thorium 232 can be utilized as fuels. After the initial charge of fuel has been provided, the fast reactor can, in theory, furnish all the electricity required in India for a total feed of only 3 to 4 tons of natural Uranium per year. Owing to high rate of heat production in the core, only liquid coolant can be employed. Water is not satisfactory as it acts as moderator. Sodium is the correct coolant, but it necessitates intermediate heat exchanger. Although initial cost of the fuel is very high, the reactor costs would be competitive, as it offers wider choice of structural materials for the core owing to neutron economy being of less importance. This reactor, however, offers considerable technical problems to be overcome before being used in commercial power stations.

Acqueous Homogenous Reactor:— This reactor employs Uranyl sulphate in solution as fuel. The solvent is light or heavy water which acts both as moderator and heat carrier. Fused salts and liquid sodium can also be used as solvents. The fuel core in the reactor is surrounded by a slurry of fertile material. There is no problem of heat exchanger in this reactor. It also eliminates the problems of fuel structural integrity under prolonged irradiation and the necessity of cladding the fuel elements. Its great advantage is the ease with which the fuel and the fertile material can be continuously processed. In the other reactors using solid fuels, either the reactor has to be completely shut down for changing the fuel or expensive 'on-load' fuel changing devices have to be employed. Handling of the highly radio-active fuel in liquid state is much easier than when it is in solid state. Moreover the fission products in the liquid fuel are not as harmful as in the solid fuel. The disadvantages of this reactor are that the slurry is abrasive and tends to settle down and that the heat exchanger becomes highly radioactive and introduces serious maintenance problem. Water at not more than 270°C corresponding to about 1500 psi is used and therefore steam conditions are average. The pumps for the slurry must be leak proof.

Britain has adopted the gas cooled graphite moderated reactor as the basic design for their nuclear power Stations. Four such reactors producing about 140 mW. net electrical output have been in use for some time at Calder Hall and one such reactor has recently been commissioned at Chapel Cross. The first of these reactors was commissioned in 1956. These stations are primarily meant for the production of plutonium for weapons and electricity is only a bye-product. Four large commercial nuclear stations of capacity ranging from 275 to 500 mW. of the improved design are under construction and these will be commissioned in 1960/61.

U. S. A. and the U. S. S. R. have both adopted the pressurised water reactors for their first civil power stations. U. S. A's first large scale prototype nuclear station is of 60 mW. net electrical output and is located at Shipping port. It was commissioned in 1957. U. S. S. R. has commissioned her first large commercial station in Siberia in 1958. This has a reactor of 100 MW net electrical output. It is a graphite moderated, natural Uranium pressurised water reactor.

Besides the gas cooled and the pressurised water reactors, the only other reactor being built for large nuclear power stations at present is the boiling water reactor. It appears that only these three types of reactors will find general application for the large commercial nuclear stations to be commissioned during the period 1960 to 1970. The other types of reactors, especially the fast breeder reactor, which is of particular importance to India owing to her large thorium deposits, are expected to come into commercial use about 1970 or thereafter. A few years ago there was a great urgency to develop the fast breeder reactors with a view to fully utilise the limited reserves of Uranium then known, but the situation has very much changed now with the discovery of new deposits. It appears that the thermal reactors will now be able to compete with the fast breeder reactor for another 40 to 50 years on the basis of the known reserves of Uranium.

It would be of interest to us in India to analyse the reasons that have led Britain and the U. S. A. to adopt different types of reactors for their nuclear power stations and these are as follows :—

1. Gas cooled graphite moderated reactor employs natural Uranium as fuel which is much cheaper than the enriched fuel used in the PWR. Production of enriched fuel necessitates a very large capital investment in a diffusion plant and entails very large consumption of electricity. The cost of electricity produced in Britain is not as cheap as it is in the U. S. A. Therefore, production of enriched fuel in U. K. would cost so much that generation of electricity with this fuel would not be cheaper than that produced by conventional stations.

2. The capital charges in U. K. are only 8-10% as compared to 13-15% in the U.S.A. Therefore, the higher initial cost of the gas cooled reactor is not so important in the U. K. as it is in the U. S. A.

3. U. K. is in urgent need of an alternative source of energy for her industries as the coal supply from her mines is lagging behind the demand. As the gas cooled reactor in large sizes is quite economical for land based power stations in that country, she is concentrating more on utilising nuclear energy for generation of power and has therefore adopted the gas cooled reactor as the basic design. On the other hand the U.S.A. has no shortage of conventional fuel and there is no urgency of utilising nuclear energy for generation of electricity in that country. She has only to prepare for the future. Her immediate aim has been the use of reactors for propulsion of ships and submarines for which purpose the compact PWR is very suitable. Her first civil nuclear power stations, therefore, are based on the PWR technology.

4. The gas cooled reactor is inherently safer than other reactors and is therefore more suitable for a thickly populated country like U. K.

U. K. is trying to improve the design of the gas cooled reactor. A new design known as the Advanced Gas Cooled Reactor is being developed. In this reactor the cladding material for the fuel elements will be either berrylium or stainless steel instead of magnesium alloy, which will permit raising of the gas temperature to 600°C thereby obtaining higher steam conditions and higher plant efficiency. The fuel in this reactor will be slightly enriched to reduce the size of the reactor and thereby cut down the initial costs. Moreover, ceramic fuel (Uranium oxide) will be used to overcome the problem of structural instability of the metallic Uranium under prolonged irradiation.

World wide interest is increasing in the heavy water moderated reactor. Britain is likely to develop a heavy water moderated gas cooled reactor as an alternative to AGCR. The main point against this reactor is the high cost of heavy water at present.

Advantages and Disadvantages of Nuclear Power Stations

Advantages of nuclear power stations are as follows :—

1. Very small quantity of fuel is required to run a nuclear station. One tonne of natural Uranium gives heat output equal to that of about 10,000 tonnes of coal. For a 150 mW station only about 50 tonnes of natural Uranium is required to run the station for a year, as against about half a million tonnes of coal required for a thermal station of equivalent size. With enriched Uranium fuel still smaller quantities are required. Fuel containing twice the normal concentration of U. 235 will give about 3 times the output available from natural Uranium fuel.

2. For the above reason running fuel costs of a nuclear station are lower than that of a conventional station at places which are far away from the coal fields or where the coal costs are high. The cost of natural Uranium in the form in which it can be used in the reactor is Rs. 250,000/- to 300,000/- per tonne. On the basis of equivalent heat output, natural Uranium fuel can, therefore, compete with coal when the price of the latter exceeds Rs. 25/- to Rs. 30/- per tonne, provided the capital charges for the plant are ignored.

3. Nuclear station is very clean. There is no nuisance of coal or ash dust. The atmosphere is not poluted by smoke, grit and sulphur dioxide.

4. Energy reserves of nuclear fuels are many times those of fossil fuels. As the fossil fuels are fast depleting, nuclear stations will eventually predominate.

Disadvantages of Nuclear Stations

1. There is a considerable safety hazard due to radio-activity in the reactor and the heat exchanger, both of which have to be adequately shielded and remote-controlled. This introduces serious maintenance problems in these units and requires the design and equipment to be of the highest order and reliability. The station is generally located far away from inhabited areas.

2. Operation of the reactor is not as simple and safe as that of the boiler furnace. It is necessary to provide a standby supply for the reactor auxiliaries like coolant pump and fans, as a failure of these can cause overheating of the fuel elements and damage to the reactor with the resultant carry over of high radio-activity to the heat exchanger. As a matter of precaution for public safety most of the reactors are provided with a dome of thick steel plate to contain the radio-active steam or vapours which may be released in the event of failure of the reactor pressure vessel.

3. As the steam conditions in nuclear station are lower than those in conventional stations, the size of the turbines and the condenser are large which adds to the cost of the plant. The overall efficiency of the nuclear station is 8-10% lower than that of the conventional station.

4. For charging and discharging the fuel during operation expensive devices are required, otherwise the reactor has to be completely shut down for this purpose. It is a costly operation as the discharged fuel, being highly radio-active, has to be remotely handled and has to be kept in underground pits for some days to allow the radio-activity to die down sufficiently before it is taken to the processing factory for the recovery of the newly formed plutonium. It is not technically necessary to remove the plutonium from the spent fuel, but as it will be used in fact reactors, it is worth recovering and storing.

5. The waste products obtained after processing spent fuel, will remain radio-active for many years and their disposal presents a serious problem. They are placed in steel or concrete containers and disposed off in deep underground pits or in the bottom of an ocean so that they cannot contaminate foodstuffs or drinking water.

6. The initial cost of a nuclear station is much more than that of a conventional station. At present only

the costs of gas cooled reactor stations are definite and these are 2½ to 3 times those of coal fired stations. The GCR Stations are too costly in small sizes, the economical size being 150 mW. or above. At present these stations cost £120/- to 150/- per kW of installed capacity against £50/- to £55/- of conventional stations. On account of this high initial cost, the nuclear stations can compete with the conventional stations only under the following circumstances :—

(*a*) Cost of coal should be about £4.5 per ton or above.

(*b*) Size of the station should be large. 150 mW. is the minimum. A station having 2 reactors each of 250 mW. output is the real economical unit.

(*c*) The station must be operated at a very high load factor i. e. about 80%.

(*d*) The station should be connected to a fully developed grid.

Probable costs of nuclear power stations being built in the U. K. and those of the contemporary coal fired stations are given in table III.

Nuclear Power Programmes

Currently U. K. is leading the world in the use of nuclear energy for the generation of power. She has programmed to commission 5000/6000 mW of nuclear power by 1965. Most of these stations will have the gas cooled type of reactors and all these will be base load stations. Previously it was thought that after 1965 nearly all the new power stations to be built in the U.K. would be nuclear stations, but now it appears that coal fired stations will continue to be built after 1965 as the cost of the nuclear stations is not coming down in the expected manner. The existing design of nuclear stations can only compete with the conventional stations when they are operated on base load and by 1965 all the base load of the national grid will be taken up by the nuclear stations. Efforts are, therefore, being directed towards developing a design which will give low initial costs of a nuclear station. AGCR, heavy water moderated gas cooled reactor and H.T.G.C.R. are being developed for this purpose.

The other countries having significant nuclear power development programmes are the U. S. A. and the U. S. S. R. These countries have tremendous resources of conventional fuel and therefore nuclear power is not going to be economical in these countries for a decade or so, except in few areas. These countries are only preparing for using nuclear energy in the future. They will each build 2000/3000 mW. of nuclear stations in the next 5 or 6 years.

The U. S. A. has great faith in the BWR, though she is building other types as well. The gas cooled reactor is finding little favour in this country. The U. S. S. R. is initially building PWR and also BWR. She is also developing gas cooled and heavy water cooled reactors.

Among the West European countries only Italy has a significant programme of nuclear stations as she is very short of conventional fuel. She has already placed orders for one 200 mW. Gas Cooled Graphite Moderated Reactor Station with U. K. and for one 150 mW. BWR station with G. E. C. of America. She intends to add about 900 mW. nuclear capacity during the next 5 or 6 years.

France and W. Germany are keenly interested in developing nuclear power, but they are at present more concerned with gaining experience of design and construction of reactors rather than adding nuclear power. Each of them may commission 400/500 mW. of nuclear power by 1965.

Sweden is building heavy water moderated reactors mainly for district heating.

The communist countries like Poland and Czechoslovakia are also building nuclear stations with the help of Russia but have a modest programme at present.

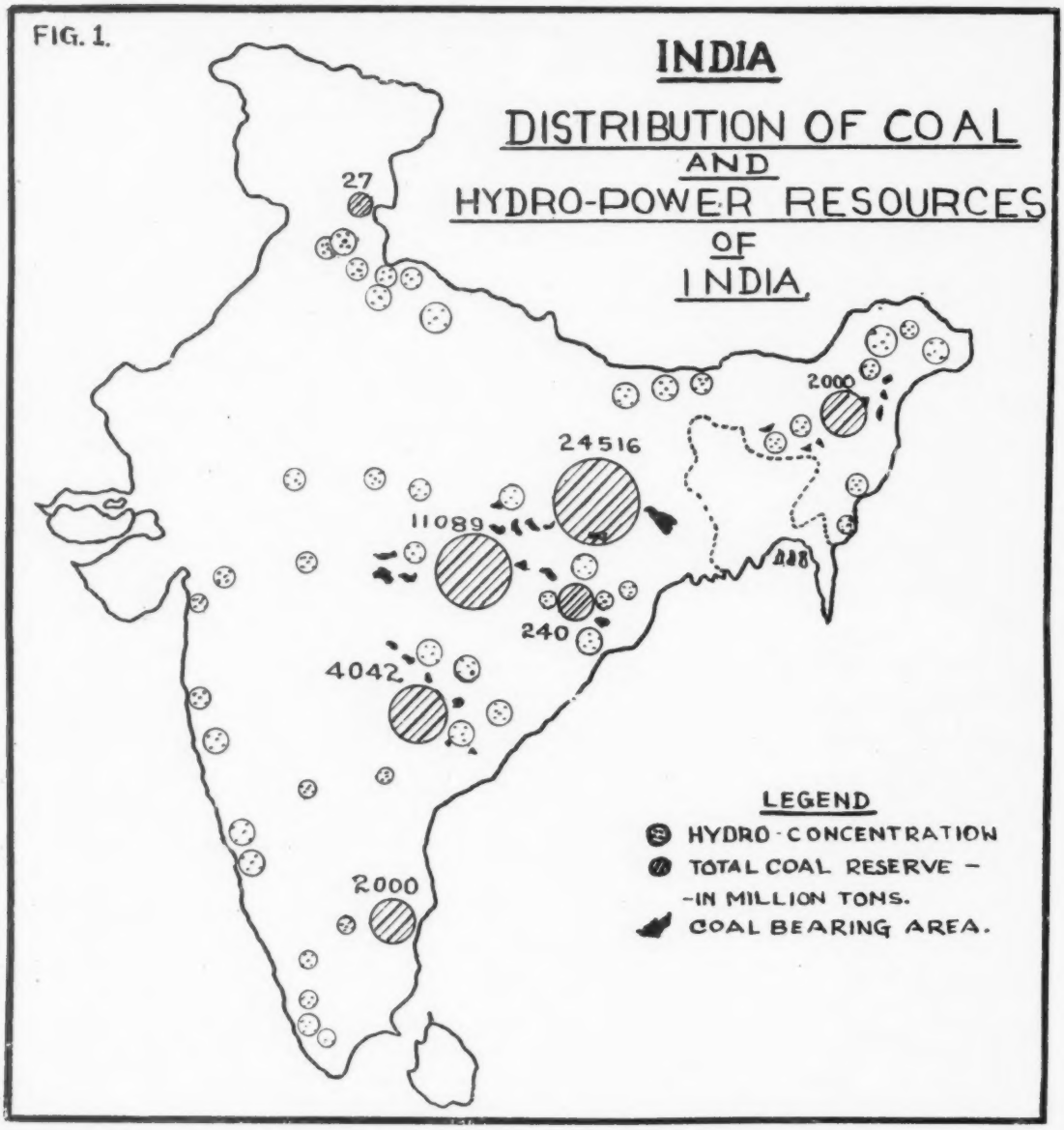
Outside Europe and North America, only Japan is keen on building nuclear power stations as she has limited conventional fuel resources. She has already placed order for one 150 mW. Gas Cooled Graphite Moderated Reactor Station with G. E. C. of U. K. She intends to add about 600 mW. of nuclear power by 1965.

Among the under developed countries India alone seems to be thinking of an ambitious nuclear programme. Dr. Bhabha has advocated to install 1000 mW. of nuclear power by 1966, which represents about one fourth of her present total installed capacity and on that score equals the U. K. programme. The Government of India have already authorised the Atomic Energy Commission to negotiate for one 250 mW. nuclear station.

Prospects of Nuclear Power Development in India

There is no doubt that India will have to make use of nuclear power on a largescale after 40 or 50 years owing to poor reserves of conventional resources for the size of her population. But for the next 15 to 20 years there is going to be no shortage of these resources except in 2 or 3 regions as can be seen from the fig.I showing the distribution of coal and water power reserves of India. These regions are Rajasthan, Gujerat and Madras. In these regions nuclear power would be competitive much earlier. It appears that the proposed 250 mW. nuclear station is to be located somewhere near Surat and same will serve Ahmedabad and Bombay areas. The cost of coal in this region is about Rs. 45/- per ton. It is not possible for a nuclear station to compete with a modern coal fired station of the same size for this coal price. Dr. Bhabha has, however, tried to prove that nuclear stations will be economical, but his comparision is between the largest modern nuclear station and the existing thermal stations in India which are much smaller than the large modern thermal stations. He has taken the efficiency of the nuclear station as 28% and that of the thermal station as 25%, whereas the modern coal fired station gives

FIG. 1.



an efficiency of 36/37%. Similarly the costs of a thermal station in his estimate are much higher than those of modern stations.

Even if it is assumed that electricity from the proposed nuclear station will be cheaper than that from a conventional station, there are certain other considerations which will not justify the installing of a nuclear station at this time. The first consideration is the serious shortage of foreign exchange. The nuclear station will cost 2½ or 3 times the thermal station and its foreign exchange component will be approximately in the same ratio. This will mean that for a 1000 mW. of nuclear capacity we will have to use over rupees 100 crores of extra foreign exchange, which will not be justified when the development of our basic industries is suffering for want of foreign exchange.

Another consideration is the employment angle. Nuclear stations will not offer employment to more persons than the conventional stations. By spending more of our naional finances and foreign exchange on nuclear stations, we will be cutting down the expansion of our other industries, thereby reducing employment prospects. At present this is an important consideration with us, as for the same reason we still encourage

[*Continued on page* 6

Table

PROBABLE COST PER kWh SENT OUT FROM NUCLEAR STATI
FACTOR AND CONTEMPORA

Rate of Interest 6 per cent, Amortisation period

ASSUMPTIONS	*Typical Mark I Nuclear Station 300 MW Net*	*Equivalent Coal-Fired Station 200 MW Turboalternators*
Commissioning Date	1961-62	1961-62
Specific capital cost	£145/kW	£55/kW
Fuel cost delivered	£17,500/tonne	£4.8/ton.
Overall thermal efficiency	27.5 percent	36 percent
Fuel Consumptions	100 tonnes/ann	0.95 lbs/kWh
Fuel Investment	500 tonnes	
Irradiation	3.000 MWd/tonne	

Cost Component	*Annual cost £million*	*Pence per kWh*	*Percent of Total*	*Annual cost £Million*	*Pence per kWh*	*Percent of Total*
Capital charges	3.81	0.435	56.5	1.44	0.165	23.5
Interest on fuel charge	0.53	0.060	8	-	-	-
Fuel Cost	1.86	0.212	27.5	4.27	0.488	69.5
Operation & Maintenance	0.53	0.060	8	.44	0.050	7
Less Plutonium	-	0.767	100	-	0.703	100
Credit at 5000/to nne	0.53	0.061	8	-	-	-
	-	0.706	92	-	-	-

Table III

R STATION HAVING TWO REACTORS EACH AT 80 PER CENT LOAD
TEMPORARY COAL-FIRED STATIONS

tion period 20 years rate of Capitalisation 8.75 per cent.

al-Fired 0 MW rnators	*Intermediate Nuclear Station 500MW net*	*Typical mark II Nuclear Station 500 MW*	*"Mark II contemporary" Coal-Fired Station 550 MW Turboalternators*
2	1962-63	1963-64	1963-64
V	£125/kW	£125/kW	50/kW
.	£17.500/tonne	£17.500/tonne	£5.3/ton
at	25.5 *per cent*	28.5 *per cent*	37 *per cent*
Th	191 *aonnes/Ann*	177 *tonnes/Ann*	0.92 *lbs/kWh*
	740 *tonnes*	600 *tonnes*	
	3.000 *MWd/tonne*	3000 *MWd/tonne*	

Percent of Total	*Annual cost £Million*	*Pence per kWh*	*Percent of Total*	*Annual cost £Million*	*Pence per kWh*	*Percent of Total*	*Annual cost £Million*	*Pence per kWh*	*Percent of Total*
23.5	5.47	0.375	52	5.47	0.375	55	2.19	0.150	21
-	0.77	0.053	7.5	0.63	0.043	6	-	-	-
69.5	3.34	0.229	32	2.99	0.205	30	7.57	0.519	72
7	0.88	0.060	8.5	0.88	0.060	9	0.73	0.050	7
100	-	0.717	100	-	0.683	100	-	0.719	100
-	0.95	0.065	9	0.85	0.058	8.5	-	-	
-	-	0.652	91	-	0.625	91.5	-	-	-

Modern Street-Lighting Practice in the U.K.

By B. K. BANERJEE

In 1934, the Ministry of Transport in the United Kingdom appointed a Committee to examine what steps could be taken for securing more efficient and uniform street-lighting. The Committee presented its final report in 1937.

Two broad classifications of lighting were recommended as given below:—

Group 'A'—Traffic Routes: Roads on which the standard of lighting should provide an ample margin of safety for all road users without the use of head-lights by motor vehicles. A mounting height of 25 ft. was recommended.

Group 'B'—Other Roads: All other roads which the responsible authority considers should be lighted. A mounting height of 13 to 15 ft. was recommended.

The recommendations contained in the Report were not intended to serve as a specification. It was subsequently felt that a Code of Practice rather than a specification would be more appropriate. Part I of the Code of Practice dealing with Group 'A' installations was published in 1952 and Part II dealing with Group 'B' installations was published in 1956.

The present practice is given below :

Group 'A' Installations

General: Traffic routes are defined as all roads forming the main approaches to or traversing important centres of population or which pass through built up areas where there is appreciable pedestrian traffic. On all roads the standard of lighting should provide an ample margin of safety for all road users without the use of head-lights by motor vehicles. The amount of downward directed light, i.e., the flux in the lower hemisphere from each lantern should be between 2600 and 7000 lumens per 100 linear feet of road where the carriageway does not exceed 40 feet in width. All spacing should be measured parallel with the axis of the carriageway.

Design : Types of installations and recommended average spacings are as follow:—

(*a*) Cut-off installations 90 ft.
(b) Non-Cut-off installations 120 ft.

On straight roads, the maximum spacing for non-cut-off installations is 150 ft and 110 ft for cut-off type. On bends, closer spacing is required. It is the general practice to stagger the lanterns on straight roads. Single side mounting is avoided as far as possible. Where there are trees or other obstacles, central suspension is used.

Mounting height is 25 ft. with tolerances of +5 ft. and $-1\frac{1}{2}$ ft. The distance between rows of lantern should not exceed 30 ft. but at the same time it is undesirable that the overhang on kerb should be greater than 6 ft. Cut-off type fittings are used at roundabouts in open country where there are no other lighting. Where the approach roads are lighted, non-cut-off types are more satisfactory.

On gradients, there may be risk of patchiness when the drivers are looking down-hill and glare when looking up-hill. In such cases, rotation of the lanterns about their horizontal axis is done. On bends, lanterns are placed on the outside of bends. This siting of the lanterns are such that as the radius of the bend decreases, the spacing is made closer, but in general, a minimum of 80 ft spacing is used.

Group 'B' Installations

General: Under this category, the emphasis of lighting shifts from the needs of a vehicle driver to those of a pedestrian and the following points are considered:—

(*a*) To light the footways adequately and to define the kerbs clearly to both pedestrians and vehicle drivers.

(*b*) To meet the requirements of the police, to provide adequate lighting of forecourts, front gardens, the lower parts of buildings and building entrances.

(*c*) To light to carriageways.

(*d*) To avoid troublesome glare, both to drivers and pedestrians.

(*e*) To avoid casting heavy shadows particularly of trees which obscure the kerbs or the view of the carriageway or footway.

(*f*) To reveal road junctions and inter-sections as clearly as possible.

Design : The lighting is invariably of the non-cut-off type except in those cases where restrictions are imposed by the proximity of an air-field or by other exceptional circumstances.

The mounting height is 15 ft with tolerances of +1 ft and −2 ft. The spacing should not exceed 120 ft. The total luminous flux provided for 100 linear ft of road should lie between 600 and 2500 lumens.

It may be mentioned in this connection that certain roads in the U. K. come under the direct jurisdiction

of the Ministry of Transport and a contribution of upto 50% in respect of the capital and running costs is made by the Ministry provided the installation conforms to the Code of Practice. However, a number of installations not strictly conforming to the Code of Practice have been commissioned and are giving satisfactory service.

Choice of Equipments

Steel or concrete columns are almost universally used for Group 'A' lighting. Modern prestressed type concrete columns measure only approximately 11″×9″. Steel columns are slightly cheaper in initial cost than the concrete type but the latter have the advantage of never requiring painting in consequence of which the overall cost taken over a period of years shows a financial saving in favour of the concrete type.

It is desirable to standardise an enclosed type fittings for although the initial cost is somewhat greater, there is a great saving on maintenance costs as a result of the fittings not having to be cleaned so frequently. Light control is either by reflection—generally anodised aluminium reflectors—or refraction. Many fittings employ outer bowls made from acrylic plastic—such as perspex—and these have given very satisfactory service in sea-coast and industrial areas where atmospheric pollution is exceptionally high. Where mercury type lighting is adopted, fittings where the lamps are in a horizontal plane, are used.

The most common method of controlling lamps is by means of time switches generally of the synchronous type without spring storage. They are cheap and reliable but have the disadvantage that they must be re-set after an interruption of supply. A double circuit switch is used with multi-lamp lanterns of the fluorescent type where it is desired to have one or more lamps switched off at mid-night and the remainder left on all night. Group control of all street-lighting in a town can be achieved by superimposing parasitic currents (D. C. or high frequency A. C.) over the distribution net-work. But the capital cost is so high that it becomes uneconomic unless the system can be used for other purposes such as load control.

Light Sources

The colour characteristics of tungsten, mercury, sodium and fluorescent type lamps are too well known to need explanation. However, when considering tungsten, its cheapness in initial cost but the high consumption of energy in relation to the light output, will have to be considered.

Mercury lamps take some minutes to reach full brilliance and will not restrike immediately if there is even a momentary interruption of supply or heavy surge during which the voltage drops by approximately 15% to 20%. They have an useful life of approximately 4000 burning hours compared with 1000 hours for tungsten. An improved colour corrected type is sometimes used but the cost is appreciably greater.

Sodium is the most efficient of the discharge type lamps but having the disadvantage of being monochromatic in colour. Like mercury lamps they take few minutes to warm up but will restrike immediately if an interruption or surge is only of short duration. They have an useful life of approximately 4000 hours. In assessing running costs, the average life of the vacuum jacket is generally taken as being five times that of a lamp.

Fluorescent lamps have an useful life of approximately 5000 hours. They restrike immediately after an interruption of supply. 'Self-start' lamps have been found to operate quite satisfactorily at temperatures below freezing point. Lamps of this type have a much lower brightness light source which minimises any glare from the lantern and visibility is consequently increased under all circumstances including wet road conditions when the comparatively narrow bright streaks on the roads from other light sources can cause discomfort.

The following chart shows the output of the above four types of lamps :—

While considering the relative economics in deciding the type of lamp, due regard should be paid to whether or not the use of mercury of sodium lighting will be suitable from the aesthetic point of view. On roads forming not the part of shopping or civic centre, colour is not so important but in such centres fluorescent type will be more suitable.

TUNGSTEN		*MERCURY*		*SODIUM*		*FLUORESCENT*	
Wattage	*Lumens*	*Wattage*	*Lumens*	*Wattage*	*Lumens*	*Wattage*	*Lumens*
100	1200	80	2320	45	2250	20	800
200	2810	125	3875	60	3420	40	1320
300	4530	250	8760	85	5525	80	4160
500	8170	400	15600	140	9100		
750	13120						
1000	18330						

The following table gives the characteristics of different types :—

	Fluorescent	*Mercury*	*Sodium*
Road Brightness :	Medium with high uniformity.	High but variable across road.	Intermediate between mercury & fluorescent.
Comfort :	Comfortable.	High brightness may cause discomfort.	Intermediate between mercury & fluorescent.
Wet-Road Characteristics :	Produces wide, soft streaks.	Produces narrow bright streaks.	Intermediate between mercury & fluorescent.
Colour :	Acceptable in all situations.	Rather cold effect poor colour rendering.	Warm effect but bad colour rendering.
Visual Characteristics :	Contrast fairly sharp & uniform across road.	Produces very sharp contrast against bright portion of road.	Produces sharp contrast.
Installation :	Siting is not un-duly critical since individual patches are large.	Errors in siting will cause dangerous patchiness.	Intermediate between mercury & fluorescent.

Standard of Lighting

It is rather difficult to make any hard and fast recommendations about the standard and type of lighting as so much will depend on local conditions apart from financial limitations on capital and/or running costs. The pedestrian and vehicular traffic load will have to be considered.

In calculating lumens per 100 ft. linear road, account has to be taken of the spacing of columns and the efficiency of lanterns. The question of maintenance is also to be considered as fittings become less efficient if cleaning is not carried out at regular intervals. Some allowance should be made for this in determining the minimum standard of lighting. Fluorescent type of lanterns require cleaning at less frequent intervals than other types owing to the fact that the ambient temperature is lower and consequently they do not attract dirt so quickly.

Lighting and Road Safety

In the U. K., the Ministry of Transport keeps statistical information on road accidents and the effect of lighting on it. Night time road journeys result in a much higher proportion of deaths and serious injuries than day time journeys. Pedestrians are chief sufferers from inadequate street-lighting, with night time death rate more than twice that by day. Roads are three times as dangerous by night as by day to each road user even though the roads carry less traffic during the night.

Economics Involved

It is very difficult to make an exact comparison between different types of lighting. But a sample analysis is made below, the units being 500 Watt Tungsten, 250 Watt Mercury, 140 Watt Sodium and two 80 Watt Fluorescent lamps, which are sufficiently comparable in effectiveness. The annual cost of street-lighting is made up of the following items :—

(1) Cost of Electricity ;
(2) Interest and Depreciations ;
(3) Cost of Lamp Replacements ;
(4) Cost of Labour, Transport.

The table below gives a broad indication of the relation between the capital cost and the annual cost of street-lighting. It should be noted that the percentages shown in each column are not directly comparable with the percentages in the other columns but only with the capital cost of each installation.

	Fluorescent 2×80 *W*	*Mercury* 250 *W*	*Sodium* 140 *W*	*Filament* 500 *W*
Cost of Electricity:	5%	10%	6%	20%
Interest & Depreciation:	8%	8%	8%	8%
Lamp Replacements:	1.5%	4%	6%	2%
Labour. Transport:	3.5%	5%	5%	6%
Total	18%	27%	25%	36%

If the overall capital cost of a column and lantern for two 80 Watt fluorescent lamps is taken as Rs. 1,000, the annual charge will be 18% of this, i.e., Rs. 180/- Similarly, if the cost of a column carrying 140 Watt sodium lamp is Rs. 800/- then the annual charge will be 25% of this, i. e., Rs. 200/-. Obviously, in practice a detailed cost analysis should be prepared before any new installation is adopted.

Silhouette Vision

When light strikes any surface at a slight angle, the surface behaves as a mirror so that drivers or pedestrians see the light sources reflected on it. Mercury discharge lamps are relatively very bright whereas sodium and fluorescent lamps have a lower brightness.

The requirement of good street-lighting can be obtained by artificial lighting of such a quantity and quality that direct seeing is attained not only by illumination of the object but also by contrast in light and shade and colour contrast. In order to reach values of illumination such as are used in interior lighting, it would require 1000 Watt lamps spaced at intervals of 16 ft. apart over the whole area. This would be simply absurd. The cost of achieving safe visibility of road and pavement is far beyond what we can afford.

The alternative is the silhouette method of vision where we see by contrast. The road surface and other backgrounds are illuminated in such a way and to such a degree that the primary consideration of an object appearing on the roadway as a dark silhouette against a bright background is achieved.

It is sometimes said that street-lighting is the cinderella of public services. But more and more we are appreciating the value of first class installations, not only as a necessity to minimise the apalling number of accidents on the road after dark but also as an amenity which attracts people.

Continud from Page 19]

Hydraulic Model as an aid in studying river problems

Proving of Model

This means how far a model is capable of reproducing with acceptable accuracy those changes in bed configurations which are known to have occurred in the prototype within a period. The principles of verification involve the proposition that if a model can be adjusted to reproduce events that have occurred in the prototype, it should indicate the events that will occur in future. Since the material used in a model is not of proper size to satisfy friction requirement for similarity, and mechanism of bed movement is not adequately known, models are built mostly on the basis of experience. The proving of a model is ultimately a cut and-try process of adjusting different hydraulic elements such as slope, roughness, discharge etc.

Model Prototype Comparison

Comparisons between model and prototype have clearly established that a satisfactory correspondence of behaviour exists within practical limits. Models assist chiefly by enabling the conditions to be visualised and have thus proved to be useful and efficient means at the disposal of hydraulic engineers for solving different problems. In many cases where the analytical method helps little because of complexities of the phenomena involved, models have been successfully used to predict the prototype conditions. Model examination has been of great help to decide in a short time the merits of alternative designs which otherwise might have been difficult. Sometimes huge savings are effected as a result. River development plans have produced excellent results based on predictions derived from model tests. Overflow spillway crests, energy dissipators etc. designed on the basis of model tests have been quite successful. Safety, economy and efficiency are the chief advantages obtained from model tests. The expenditure on model experiments is but a small percent of the cost of structures to which they relate.

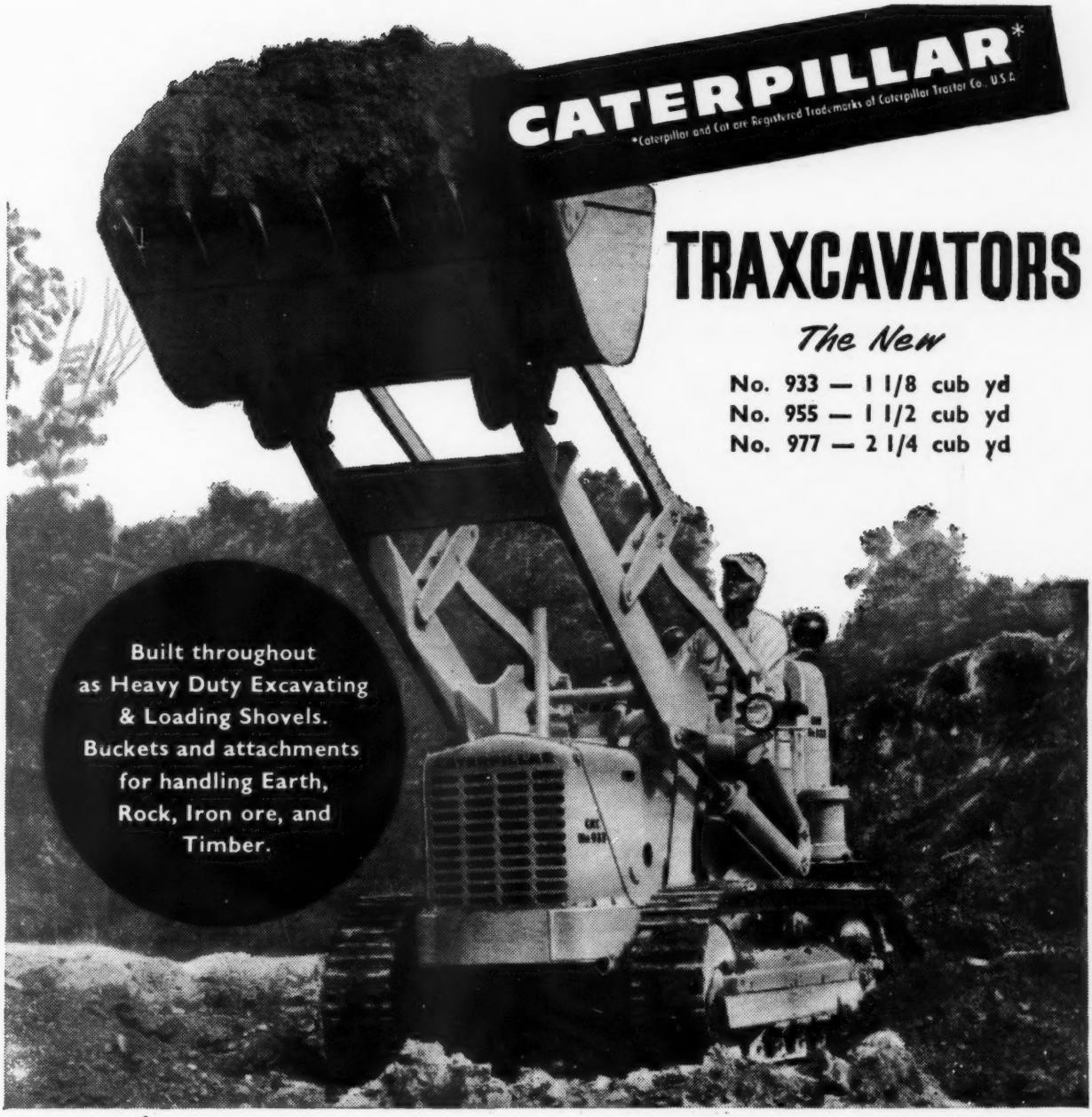
Limitations

Inspite of remarkable achievement and popularity of hydraulic model studies one must not be tempted to regard models as some sort of automatic solution of hydraulic problems. Limitations there are and limitations of models should be properly assessed. Models are no doubt, valuable adjuncts to analysis and judgement, but they are not infallible. They yield information and data which require careful analysis. Blind reliance on them without proper analysis may prove disastrous.

A model is designed and operated according to some laws of similitude which is seldom satisfied and the resulting limitations must be respected. The fact that 'g' cannot be impaired necessitates a definite limitation on model results. The scale effects and lack of representative character of bed material to simulate prototype behaviour also set limitations to model results. But despite the limitations and uncertainties involved, use of models is definitely superior to any other method of approach. It is why model test has become progressively significant as a means of ensuring the general excellence of modern design procedures.

References

1. Hydraulic Laboratory Practice—J. Freeman.
2. Applied Fluid Mechanics—O'Brien & Hickox.
3. Engineering Hydraulics—H. Rouse.
4. Handbook of Applied Hydraulics—C. V. Davis.
5. Scale Models in Hydraulic Enginnering—J. Allen.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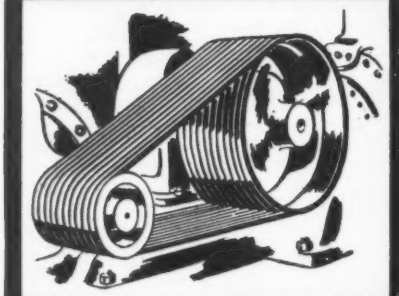

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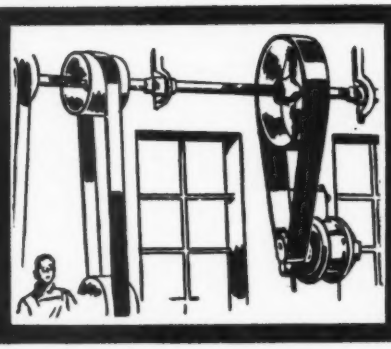

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Hydraulic Model as an aid in studying river problems

S. N. SARKAR

The science of hydraulics is of great antiquity and is essentially built up of a number of formulae which are empirical in nature. Although great advancement has been made during recent years in the field of fluid dynamics, yet hydraulics cannot he regarded as an exact science. The laws governing the fluid phenomena are still imperfectly understood and analytical study often proves difficult, as a result of which recourse is to be made to model experiments.

Investigation by means of models has now-a-days been very popular and found to be of great help in solving different problems which are not amenable to theoretical treatment. But the technique appears to be a pretty old one. M. Gariat, an Italian Engineer is stated to have investigated in as early as 1760 the effects of the effluents of the Rhine on the waterlevel rise by means of model. With passage of time and development in the mechanical field, the technique has undergone rapid change and improvement and model testing has become indispensable to-day.

Concept of a Model

A model is usually defined as a system by whose operation the behaviour of some other system may be predicted. It is evident that this definition lays stress on the similarity of characteristics without any implication as to its appearance, although the popular conception is that it should be a small scale reproduction of the prototype. This will mean geometrical similarity which is no doubt convenient, but considerable departure often becomes a necessity and this will be dealt later. The essential factor in the design and operation of a model is that the state of flow in the prototype will be simulated in the model. "A model", states O'Brien" may be regarded as a mechanical means of solving differential equations of fluid motion for a given set of boundary conditions, the essential requirement being that it be possible to establish quantitative rules for transferring the data to the prototype." This is indeed a comprehensive definition of model elucidating the purpose of model tests. But one word of caution seems needed about the term "mechanical means" which is often misunderstood. A model does not offer a solution in itself, but provides merely a powerful tool on the efficient handling of which depends success to a great extent.

Model Laws

In order that the results obtained from model tests can be applied with confidence to the prototype, certain laws must be satisfied. The principles upon which the model procedure is based comprise the theory of hydraulic similitude, involving geometric, kinematic and dynamic similarity. Geometric similitude postulates similarity of form, kinematic similitude similarity of motion and dynamical similitude involves similarity of forces acting on the systems. The principal physical forces controlling the fluid motion are inertia, gravity, viscosity and surface tension. The relationships of these forces may be expressed in the form of dimensionless groups which characterise by their numerical values the type of flow under consideration. It has been found that for equal values of these characteristic numbers, the corresponding flow patterns in the model and the prototype become identical. The characteristic numbers (or dimensionless parameters as they are called) commonly used in models are Froude, Reynolds and Weber numbers. Besides, there are a few other such parameters which are not of practical importance in ordinary river problems. The Froude number is expressed as $F = \frac{V}{\sqrt{L.g}}$ being the ratio of inertia and gravity forces. The Reynold's number $R_e = \frac{V.L.\rho}{\mu}$ is the ratio of viscosity and inertia forces and the Weber number $W = \frac{V.^2\rho.L}{\sigma}$ is the ratio of surface tension and inertia. In the above notations L=a linaar dimension, v=velocity ρ=density, μ=viscosity, σ=surface tension of the fluid and g=acceleration due to gravity.

The larger the inertial reaction to any force the larger is F, and a smaller value of F indicates larger influence of gravity. Model studies of flow involving a free surface are based upon the Froude criterion of similitude. If F is same then the relative magnitude of gravity forces is also same in both the cases.

The larger the value of Re the smaller is the effect of viscosity in determining the flow pattern. The smaller the value of Re the greater is the relative magnitude of viscous effects. Equality of Re in both model and prototype indicates similarity of flow characteristics where viscosity and inertia are the governing forces. The effects of gravity and surface tension are neglected in this case. The Reynold's number is also used as a criterion for laminar and turbulent flow in a system. The case of flow in pipes may be taken up as an example.

It is known that the loss of head for viscous flow in pipe is given by $h = \frac{32\,\mu.v.l}{\rho g.d^2}$ .. (i) while for turbulent flow $h = \frac{f.l.}{v} \cdot \frac{v^2}{2g}$ .. (ii) i. e. head loss is $\propto$ v in the fisst case and $\propto v^2$ in the second.

For Re $\angle$ 2000 (approx.) the equation (i) is applicable and for Re $\nearrow$ 2000 the equation (ii) is to be used. When the dimensions are reduced in a model Re may fall in the region of viscous flow, whereas the flow in the prototype might actually be turbulent. Thus in the design of a model it is essential that Re falls in the same category as in the prototype.

There are many cases of flow in which gravitational as well as viscous forces are important. It is necessary that both F and Re should be satisfied simultaneously for ensuring complete similitude. Unfortunately, this is physically impossible if the same fluid is used in the model and prototype. For, the Reynold's number requires that $V \propto \frac{1}{L}$ and the Froude number demands that $V \propto \sqrt{L}$ which cannot be satisfied simultaneously unless the model scale is 1: 1. i. e. same as the prototype.

Theoretically it may be possible to select a model fluid of particular viscosity so as to attain complete similitude, but practically the choice of fluid is too limited to preclude its use. Water being abundant in nature is generally used for this purpose. A compromise is therefore, to be achieved in the practical case by considering which of these forces is more important and the model flow will be regulated in accordance with this primary parameter.

Yet the design of a model is not always so easy that the mere application of one or other of these dimensionless parameters will suffice. It is essential to keep clearly in mind that all conditions in the model and prototype must remain similar within the range of measurements. The limits within which transferability is permissible must also be understood. It is not surprising for these reasons that the basis for reasonably accurate prediction about the prototype behaviour from model experiments has in many cases been one "compounded of experience and intuition." But it should never be inferred from the above statement that prediction from model is merely a guess work without any scientific basis which is far from truth. All that it means it is a difficult task calling for intellect, patience and careful judgement of the investigator.

Types of Models

Hydraulic models may broadly be divided into two groups (i) models of structure and (ii) river models. The former is generally a rigid bed one, while the latter may be either (i) rigid bed or (ii) movable bed models. They may again be distorted as well as undistorted models. Models of dams, spillways etc. have to be made to an undistorted i. e. geometrically similar scale. In fact, all works in which standing wave is a feature are to be modelled to geometrically similar scales.

In case of river model, problems in which changes in bed configuration are not critical are generally studied in rigid bed models. They have been useful in investigating the navigation conditions and backwater effects etc. But problems involving scour, deposition or transportation of material through the action of flowing water are studied in a movable bed model. The design principles are same in both the cases with the exception that the tractive force comes into consideration in the latter. The design and operation of tidal river models are kept out of this account in which besides other factors, simulation of tide, silt charge and salinity is to be effected.

Design of Models

The guiding factor in the design of a model is the nature of the problem to be studied and the accuracy desired. The design of a model thus requires consideration on the following points (i) results to be expected (ii) availability of space, water and other materials and finally (iii) cost. From the practical view point, a model should be built large enough so as to permit collection of data with reasonable accuracy, while economy consideration demands that it should be built as small as possible and still yield valid results. The size of a model ultimately depends on the features of flow which are of interest and possible accuracy of measurement. Large scale models are usually built in the open field, while small scale models are indoor ones. If the lines of symmetry are expected to occur sectional model many be built by substituting solid boundaries for the lines of symmetry.

Next is to be decided whether this will be a rigid or movable bed one. In a fixed bed model the influence of wall resistance is of major importance, whereas in a movable bed model movement of bed materials as well as changes in channel configurations are the principal elements that are to be correctly reproduced. The model scales and proper bed material must be carefully chosen in the latter case. In a fixed bed model the friction factor can be adjusted by altering the character of the surface till proper water surface slope is obtained at a known discharge but this is not practicable in a mobile bed model by controlling bed material size. The choice of bed material for a movable bed model must be based on their characteristics as regards movement.

In fact, movable bed models present much more difficulties in design and operation and also yield less satisfactory results. The conformity is poorer when the phenomena of scour and deposition are involved. A properly constructed movable bed model is no doubt capable of predicting tendencies towards erosion or deposition of materials but the results are mostly qualitative in character. This is because the laws governing bed movement are imperfectly known. On account of scaling down the prototype dimensions in a model, the reduced hydraulic forces are no longer sufficient to move the bed material of a workable size. While attempts have been made to use lighter materials such as lignite, haydite etc. in some cases, the practical way of overcoming this difficulty is to introduce distortion of model scales.

Distortion can be effected in a number of ways such as, by (1) increasing slope from tilt of the model (ii) arbitrarily changing the discharge scale (iii) changing

bed roughness or (iv) using different horizontal and vertical scales. The last one has found wide application in the practical field. But too much distortion is also not permissible. As a rule, the distortion of scale ratios should be kept low so that the flow regimen may not get disturbed. Excessive distortion may result in the increase of bank slope beyond the angle of repose so that it will no longer stand. Distortion normally varies from 2 to as high as 10 or more in special cases.

The advantages and disadvantages of distorted and undistorted models may be discussed now. An undistorted model reproduces flow phenomena accurately, but its disadvantages are that (i) the surface slope becomes extremely flat, (ii) depth small and (iii) it is difficult to produce bed movement.

A distorted model on the other hand has advantages in that (i) it produces sufficient tractive force to move bed material (ii) water surface slope steeper and (iii) depth considerable. But the disadvantages are the magnitude and distribution of velocities may be incorrectly reproduced when distortion is excessive.

The scale effect i. e. too small a model has not been placed on any rational basis. It is often useful whenever possible to study a particular problem in two or more models of different scales in order to assess the scale effects on the model results.

Model Scales

Model scales refer to scale ratios of linear dimensions. There is generally a minimum size for a model, built smaller than which it presents difficulties in the collection and interpretation of data. Too great a reduction in the size of amodel may result in tractive forces which are smaller than critical tractive force necessary to initiate bed movement. It often leads to viscous and capillary influences which render model performance open to doubts.

But there is no rigid rule about model scales. An investigator on the basis of experience may select any suitable scale and get satisfactory results.

We have, on the basis of Froude's law,

$$\frac{V_r}{\sqrt{L_r\, g_r}} = 1$$

Using the same fluid as in the prototype, the model-prototype relationships for various hydraulic elements will be as follows :

If the length scale is L_r, then,

$$\left.\begin{array}{ll} \text{Velocity scale} & V_r = L_r^{\,1/2} \\ \text{Discharge scale} & Q_r = L_r^{\,5/2} \\ \text{Slope scale} & S_r = 1 \end{array}\right\} \quad \ldots\ldots\ldots (1)$$

Here the subscript r denotes the ratio of model and corresponding prototype values. The length scale in this case determines the size of the model.

On the other hand, for distorted models with different horizontal and vertical scales, analysis can conveniently be made by using Manning's formula

$V = \frac{1.486}{n} . R^{2/3} . S^{1/2}$, R being hydraulic mean depth

n=coeff. of roughness and the following relationships will be obtained.

$$\left.\begin{array}{l} V_r = \dfrac{1}{n_r} \cdot \dfrac{D_r^{\,7/6}}{L_r^{\,1/2}} \\ Q_r = \dfrac{L_r^{\,1/2} . D_r^{\,13/6}}{n_r} \\ S_r = \dfrac{D_r}{L_r} \end{array}\right\} \quad \ldots\ldots\ldots (2)$$

Here L, D and n denote length, depth and roughness factors respectively.

If gravity and friction forces are to be satisfied simultaneously, then by equating the velocity ratios in (1) and (2) we get,

$$D_r^{\,2/1} = \frac{D_r^{\,7/6}}{n_r . L_r^{\,1/2}}$$

or

$$n_r = \frac{D_r^{\,2/3}}{L_r^{\,1/2}}$$

For an undistorted model this becomes $n_r = L_r^{\,1/6}$ Since, the tractive force T is given by

T=W. R. S., W being unit weight of water. And from Manning's equation,

$$S = \frac{n^2 . v^2}{(1.49)^2 . R^{4/3}}$$

$$\therefore \quad T = \frac{w . n^2 . v^2}{(1.49)^2 . R^{1/3}}$$

or

$$T_r = \frac{n_r^2 . v^2}{R_r^{\,1/3}} \simeq n_r^2 . D_r^{\,2/3}$$

Attempts have been made to express critical tractive force in terms of bed material properties. According to Krey $T_c = .6\, d$, d being median diameter of particles in inches, T_c=critical tractive force. The foregoing equations will determine the dimensions of a model. In addition, turbulent motion as exists in the prototype is to be ensured in the model for which the following relation must be satisfied.

$$\frac{VR}{\nu} \geqq 4{,}000 \text{ or } v.R \geqq .04 \text{ (approx.)},$$

v being velocity, R=hydraulic mean depth and ν=kienatic viscosity of liquid.

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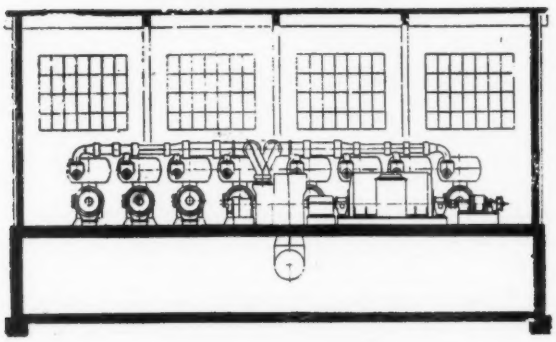
Developments of Free-Piston Turbine Drives in Europe

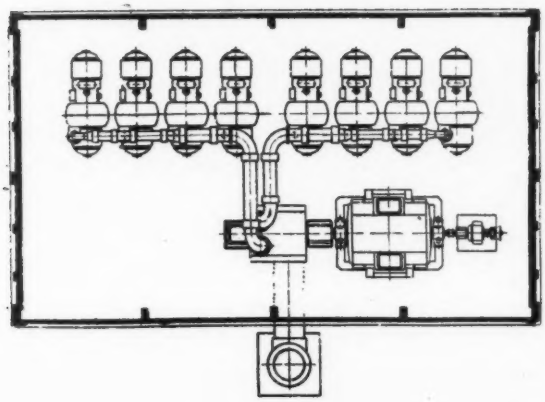
Free-piston turbine drives are fast taking their place as prime movers in Europe. This survey will present some of the design considerations and the benefits for the power engineer for the use of this novel engine type. At the present its actual application as a prime mover is somewhat limited, but this might change rapidly.

By LEO WALTER

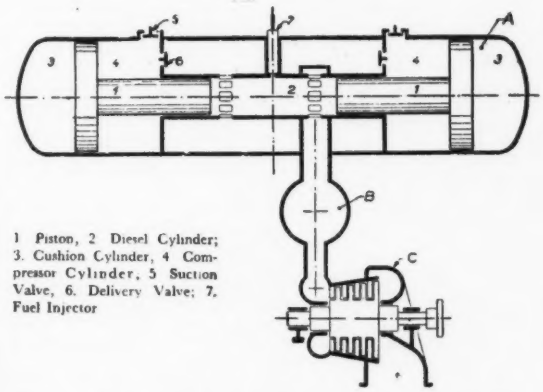
The free-piston gasifyer may be considered as a super-charged diesel engine, working on the two-stroke cycle, with opposed pistons. It does not itself supply mechanical power but generates power gas which is used in a gas turbine. The G. S. 23 gasifyer generates the equivalent of about 1,000 h.p., and up to ten units may feed gas to a single turbine, which may be coupled directly to the driven machine or to reduction gears. Two turbines can be connected to a single reduction gear, so that sets can be arranged for powers from 1,000 to 20,000 h. p.

Layout of 6,000 kW Power Station using Free-piston Electrical sets





In Fig. 1 A represents a gasifyer which delivers gas through a gas collector (B) to the gas turbine (C). In the gasifyer itself, (1) is the engine cylinder, in which the opposed pistons (2) work. Fuel is injected at (3). The compressor cylinders (4) draw in air at suction valves (5), and deliver the supercharged air to the firing cylinder through the valves (6) and ports (7). The gas passes to the collector and turbine through the ports (8). The cushion cylinders (9), which contain air compressed on the outward stroke, provide the energy to return the pistons on the inward stroke.



1 Piston, 2 Diesel Cylinder; 3. Cushion Cylinder, 4 Compressor Cylinder, 5 Suction Valve, 6. Delivery Valve; 7. Fuel Injector

Fig. 1. Free-piston gas generator and gas turbine set.

Courtesy : S. I. G.M.A., Paris and Lyons.

There are neither connecting rods nor crankshafts, and the two pistons are kept in phase by a light linkage which does not transmit driving power. The stroke and dead-centre positions of the pistons vary according to operating conditions. Because of the variable compression ratio, starting (by compressed air) is immediate from cold.

Among the gasifyer's outstanding advantages is its freedom from vibration, since the moving masses are opposed and perfectly balanced. The elimination of connecting rods and crankshaft makes it much smaller and lighter than a conventional diesel engine of the same output. Since the gasifyers and gas turbine are not mechanically coupled, their position may be arranged to suit the requirements of the individual installation, and in sets where several gasifyers are employed, it is possible to shut down each in turn for inspection or maintenance whithout interfering with the power output.

Technical Particulars of GS. 34.

Engine cylinder diameter	13.4 in (340 mm)
Compressor cylinder diameter	35.5 in (900 mm.)
Stroke	15.75 in to 19.7 in (400 mm. to 500 mm.)
Speed, cycles per minute	350 to 600
Gas pressure	43 p.s.i.g. (3.0 kg/cm²)
Gas temperature	825 deg. F. (44° deg.C)
Gas delivery	8.8 lb/sec. (4 kg/sec).
Max. continuous rating	1,250 gas horse power, equivalent to 1,000 b.h.p. or 720 kW approx.

The sets are able to deliver an overload of 10 per cent. for one hour.

Heat dissipated to cooling water 17 per cent. of heat in fuel

Heat dissipated to piston cooling oil	7 per cent of heat in fuel.
Weight	8 tons.
Height (excluding gas collector etc.)	4 ft. 6 ins. approx.
Overall length	14 ft. approx.

Fig. 2 shows a sectional arrangement of the Gs. 34 gasifyer, as manufactured by the National Gas and Oil Engine Co. Ltd. of Ashton-under-Lyne, England.

The change-over from gas to heavy fuel oil is carried out very easily, without having to alter the control settings of the gas-generators.

The low specific consumption, the use of heavy fuels, the ease of maintenance and the high utilization factor make the industrial operation of free-piston sets very economical. (fig. 3)

The free piston-gas turbine combination belongs to the generic class of compound, internal combustion prime movers. In any compound scheme a displacement type of pressure trasformer (in practice a cylinder and piston element) is associated with a rotating aerodynamic flow machine (in practice a gas turbine). The principle of compounding has well known thermodynamic advantages leading to a low fuel consumption. The advantages arise in that each element of the compound scheme handles the appropriate part of the thermodynamic cycle. That is, the piston element handles the high pressures and the turbine element handles the large volumes. An efficient cycle demands that pressures should be higher than a turbine can readily handle and that volumes should be larger than the piston can easily accommodate.

The fuel economy which can be shown in several applications of the free piston gas generator, is mainly the result of compounding. However, when an attempt is made to pool the good qualities of two dissimilar partners, the danger is always present of mixing the wrong qualities instead. The free piston principle is one of the very few practical methods which have made it possible to use the theoretical advantages of the compounding principle. For this desirable condition the properties of the free piston enumerated earlier are largely responsible.

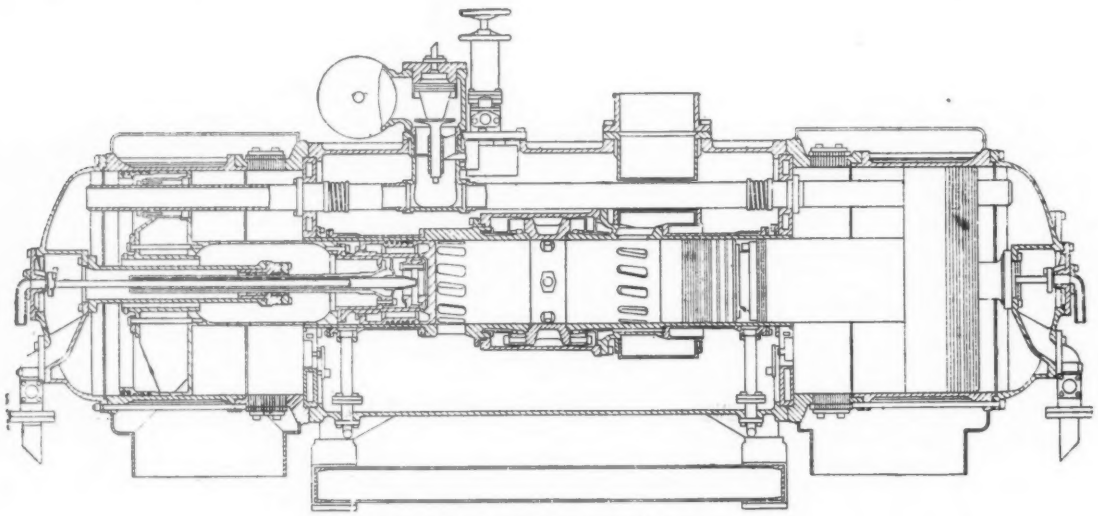
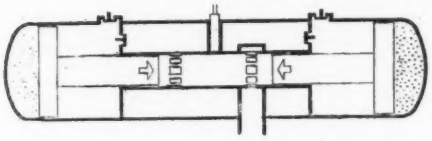


Fig. 2. Section through grsifyer.

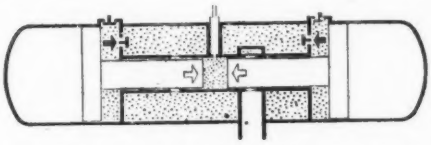
Courtesy : National Gas and Oil Engine Co. Ltd.

The over-all efficiency of a free-piston gas-generator and turbine set depends on the efficiency of the turbine and increases with turbine power. Specific consumptions of 170 gr. /ch./hr. (38 lb/hp/hr) measured at the turbine shaft have been recorded for 2000 hp sets.

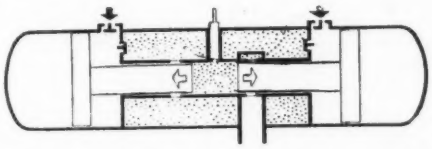
The size of the engine cylinder, the temperature and pressure levels during combustion, the large quantity of excess air and the quality of the scavenging explains the ability of the free piston gas-generator to use the heaviest fuels.



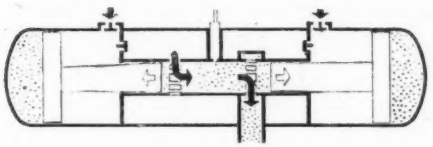
1. *Starting Position. The pistons are at the outer dead point. Scavenge and exhaust ports are open. All valves are closed. Starting air under pressure is admitted to the cushion space and pistons are driven inwards*



2. *Position shortly before the Inner Dead Point. The diesel pistons cover the scavenge and exhaust ports and compress the air in the diesel cylinder. Air in the compressor cylinder is compressed by the inward movement of the compressor piston and is discharged through the delivery valves into the engine case*



3. *Expansion in the diesel cylinder and suction in the compressor cylinder. After fuel injection and ignition the opposed pistons are driven outwards. The compressor pistons draw in atmospheric air, at the same time compressing the air in the cushion space to store up return energy*



4. *Position shortly before the Outer Dead Point. The exhaust ports are uncovered and combustion gases escape to the gas collector. Shortly afterwards the scavenge ports are uncovered and compressed air in the engine case scavenges the diesel cylinder and flows to the gas collector and mixes with the combustion gas to provide a gas-air mixture at about 45 lb per sq in and 850 degrees F to drive the turbine. Compression of the air in the cushion spaces brings the pistons to rest at the outer dead point and then drives them in again to commence the next cycle.*

Fig. 3. How the gasifyer works

Courtesy : Allen Munty & Co. Ltd.

Efficiency

The specific fuel consumption on a shaft horse power basis depends on the turbine efficiency, on the gas transmission losses and the losses in the reduction gear. All these depend to some extent on circumstances such as the size of the set and the speed of the output shaft, i.e., the number of stages of gear reduction.

Typical efficiencies at full load may be given for a well-designed 2000 hp set with a singlestage reduction gear, as follows:

Thermal efficiency of gas-generator into gas, 43 percent; Turbine efficiency, 88 percent; Gas transmission (loss 2 percent) efficiency, 98 percent ; Reduction gear (loss 3 percent) efficiency, 97 percent. This results in an efficiency on a shaft horsepower basis of 36 percent. The specific fuel consumption for a calorific value of 10,150 chu per pound (18,300 btu/pound) would then be 0.386 pound per shp/hour. This figure is about the best that can be obtained at present for a continuous duty rating, and it does not include an allowance for power absorbed by auxiliaries.

Figure 4 shows the variation of turbine-torque with speed, and the corresponding power and efficiency, as percentages of the values at the optimum speed.

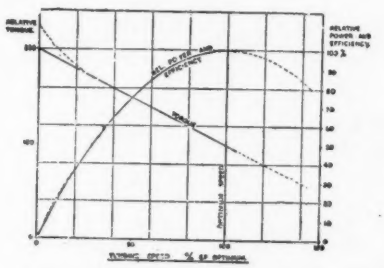


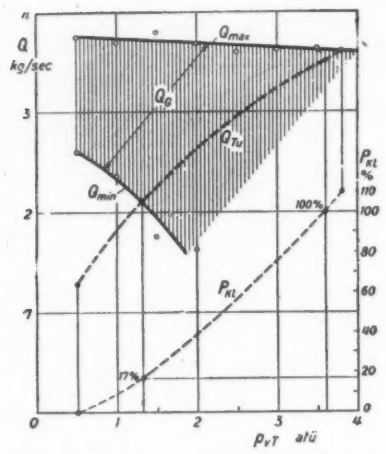
Fig. 4. Turbine-Torgue drops as speed, Power and Efficiency increase.

Turbines are normally designed with a maximum speed no greater than the optimum, but where a large ratio of starting torque to full speed torque is required, the design can be modified (chiefly by providing a larger number of stages) in such a way that it has a somewhat higher torque at very low speeds, and so that it can be run at speeds well above the optimum, as shown by the broken lines.

Features of Coupling Gas-Generator to Turbine

The gas pressure and temperature conditions are very favourable for the turbine in a gas-generating plant. The gas inlet temperature to the turbine is about 500 C, at full load, and is considerably lower than could be used in normal gas turbines with a good efficiency. The pressure range between 5 and 1 atm. abs., on the other hand, corresponds to the most favourable mean pressure zone of a steam turbine plant, and good turbine efficiencies can therefore be expected for moderately large units.

The power output is not controlled by throttling or partial admission as in a steam turbine, but it is done entirely at the gas-generator, varying the gas pressure at the turbine by adjusting the quantity of gas delivered to the requirements of the turbine. The maximum and minimum gas flow which can be supplied by the generator are shown at the inlet to the working pressure at the inlet to the turbine. By taking the gas flow through the turbine from the curve Qtu (Fig. 5),



P_{vT} working pressure at inlet to turbine
Q quantity of gas delivered to gas generator, Q_G range of delivery of gas generator, Q_{TU} intake capacity of turbine, P_{Kl} useful power output of plant at terminals in % of full load.

Fig. 5. Gas Turbine Output is controlled by variation of gas pressure.

at each working pressure, and multiplying this mass flow by the heat drop, the curve of power output P_{kl} againts tworking pressure pvT readily determined. The range of power output at the terminals of an electric generator is from 100 percent down to 17 percent of full load. The power output of the plant can thus be controlled over this range directly from speed governor of the turbine acting on the fuel pump rack of the gas-generator. For power outputs less than 17 percent with only one gas-generator, part of the gas would have to be blown off.

The gas-generator, being a piston engine, delivers gas in a pulsating flow, but as a constant rate of flow to the turbine is desirable, a means of equalizing the delivery to the turbine is required. This can be done without using large collecting vessels, by supplying the turbine from two or more gas-generators. In a plant consisting of several gas-generators a considerable amount of equalization is to be expected, because even with gas-generators of identical design and equally loaded, the speed in cycles per minute will vary slightly. (fig. 6)

In a multi-gas-generator plant, individual gas-generators can be shut down for maintenance without interruption of the operation of the plant as a whole. A proportion of 1 gas-generator in 4 or 1 in 6 is all that need be provided for standby equipment to permit continuous operation of the plant throughout the year. The existing evidence is that no standby turbines are required.

Owing to the high maximum temperatures and pressures in the diesel cylinder and the large amount of excess air, the free-piston gas-generator is particularly well adapted to burning a wide variety of liquid fuels (including heavy residual oils and crude). The engine is comparatively insensitive to the fuel which may be changed with very little, if any, adjustment to the plant.

The over-all efficiency, while not perhaps as good as that of the best diesel plant, is good, e.g. 34.8 percent at the alternator terminals on the 6000 kW generating set at Cherbourg, France.

Owing to the simplicity of construction of the gas-generator and the absence of crankshafts, connecting rods, mechanically operated valve gear etc., the man-hours required for maintenance are appreciably less than in the case of the diesel engine, i.e., the time required to remove the diesel pistons, replace the top

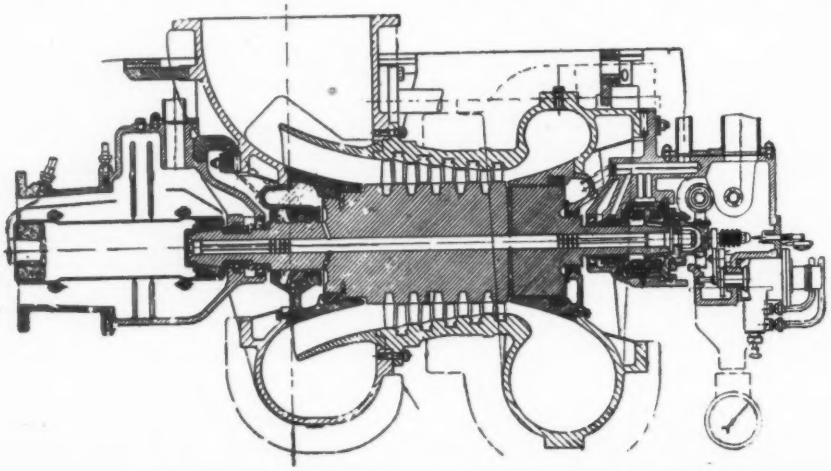
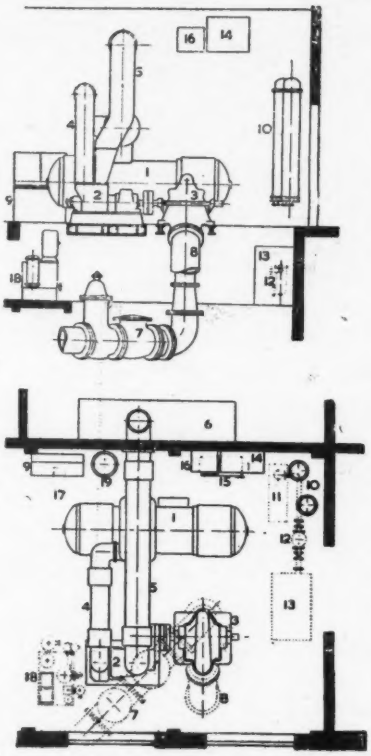


Fig. 6. Brush Gas Turbine to work with Free Piston Gasifyer.

Courtesy : Brush Electric Co. Ltd.

piston ring, refit the pistons and start up again, is approximately one hour. (fig. 7.)



1. One GS34 free-piston gas-generator.
2. Turbine and reduction gear.
3. Centrifugal water pump.
4. Gas pipe to turbine.
5. Exhaust pipe.
6. Air filters.
7. Water suction pipe.
8. Water delivery pipe.
9. Control desk.
10. Oil and water heat exchangers.
11. Electrically driven oil circulating pump.
12. Oil filter.
13. Oil tank, piston cooling and synchronizing linkage lubrication.
14. Water tank.
15. Electrically driven water circulating pump.
16. Oil tank, mechanical lubricator feed to cylinder.
17. Electrically driven fuel pump.
18. Oil tank, filter, and heat exchanger for turbine and reduction gear lubrication.
19. Air bottles.

Fig. 7. 1000 h.p. Free-Piston Gas Turbine Set pumping water at Suresnes, Paris.

Courtesy : S I. G. M. A., Paris

The exhaust heat can be used to raise process steam at pressures up to 100 psi. without burning additional fuel. Alternatively, since the gas delivered by the gas-generators contains 80 percent unburned air, additional fuel can be burned, either in a pressurized boiler between the gas-generators and the turbines, or in a normal boiler downstream of the turbines. The steam generated can either be used for process work, or for generating additional power, e. g., 8 gas-generators combined with a steam cycle can produce 25,000 kW as compared with 6000 kW on their own. The over-all efficiency of such a mixed cycle set is about 7 percent higher than the efficiency of the steam side.

Since the two piston assemblies of the free-piston gas-generator are of the same weight and move in opposite directions, there are no out-of-balance forces or vibration, and no heavy foundations are needed. This, combined with the low-over-all height of such a plant, tends towards a saving in cost of foundations and building.

Each of the points mentioned above has a favourable economic effect and their total influence on the over-all economies of such a plant.

Bibliography

J. Smith—A Partner for the Gas Turbine. Publ: The Technical Journal of the Brush Group, London, S. W. 1. Autumn, 1957.

Leo Walter—Europe Likes Free-Piston Turbine Drives. Publ: Petroleum Refiner, Houston, Texas, August, 1957.

Beale & Watson—Paper presented to Diesel Engineers and Users Association, London, January 1956.

Free-Piston Gasifiers, Publ: The Oil Engine, London, Aug. 1953.

G. Fickelberg—The Free-Pistons Gas Generator. Publ: Schweizerische Branzeitung, Nr. 48. & 49, 1948 (in German but translation available).

F. Picard—A New Gas Turbine Locomotive with a Free-Piston Gas Generator. Publ: Revue Generale des Chemins de Fer, Paris, May 1952 (in French, but translation available).

J. S. Shapiro—Free Piston Engines. Publ: The Times—Review of Industry, London July, 1955.

[*Continued from page* 1

Thermal Power Station at Durgapur

Due to the condition of the soil concrete piles were used for the power plant site and saved about 2000 tons of steel. Economy has been effected by the semi-outdoor location of boilers, fans, preheaters and dust collectors. All other equipment such as turbo-generator units, switchgear and auxiliaries are installed indoors. Maximum space/kW has been achieved with a high standard of operating efficiency and maintenance system. Economy, efficiency and multipurpose facility have all been achieved in planning the project.

All feed water pipes and pumps are on the ground floor; switchgear are on the mezzanine floor.

The control room is suitably located for efficiency of operation, safety and minimum lengths of power and control cables. The water level of the boiler and the condition of the flame in the boiler furnaces are indicated by television screens.

This power plant is one of the largest thermal plants in India and has exceeded the capacities of the Bokaro thermal plant of the Damodar Valley Corporation and the Trombay plant of the Tata Power Company at Bombay. This augurs well for the future developments in the coal belt areas.

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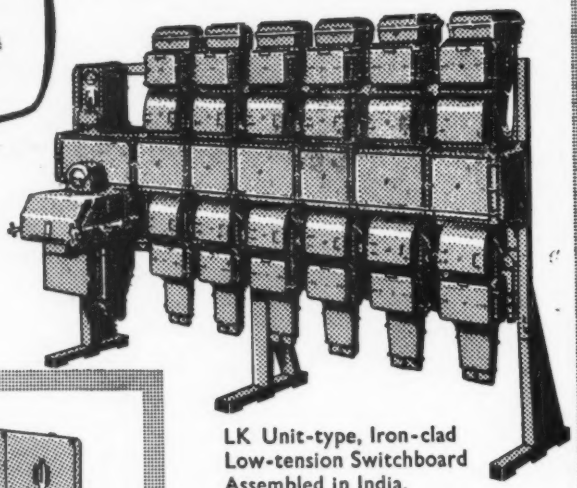

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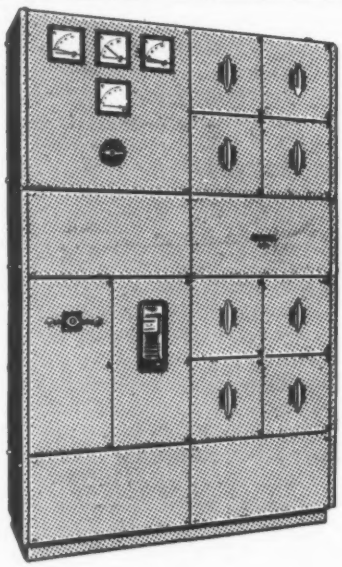

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Trends in the Design of Dams and Construction of River Valley Projects

By V. RAMA RAO

Engineers are judged by the work they turn out. The world sees the finished article and expresses its opinion but the engineer knows in his heart whether or not he has achieved his purpose. The final cost of the project is the main important thring from his point of view. So he must always have his mind's eye glued to this important aspect of the project. The cost of the project depends on the economic designs of its component parts. Hence the designs of the hydraulic structures play a paramount part.

Before any river valley project is taken up for construction, preliminary surveys, field investigations and studies about the river and catchment areas are quite essential. The preliminary studies to be undertaken are (1) hydrology of the river, (2) geology of the foundation, (3) study of temperature of air and river water, (4) rainfall (5) type and nature of the catchment, (6) nature of lands coming under submergence, (7) number of families to be displaced. The surveys to be conducted are (1) soil surveys (2) area capacity surveys, (3) surveys for economic alignment of the structure and (4) investigations for quarries and borrow areas. A comprehensive report based on the findings of these studies, surveys and investigations forms the basis for the final design of the hydraulic structures involved in the project.

Irrigation engineer serves a hard and unforgiving mistress and water will seldom forgive any small miscalculations or mistakes in the design or construction of works. It is quite essential therefore that the structures are to be designed with the utomst care taking into account all the data available. Irrigation problems are complex and most of them are not susceptible to correct mathematical treatment. It has therefore been felt that through model experiments and research safe and economical designs can be done. The hydraulic features must be regarded as fundamental in the design of projects. The structures must be fashioned so as to cause the water to flow with the desired characteristics. The governing hydraulic features of a project should be thoroughly understood by the designer. Certain dimensions and forms of the structure can be obtained by calculations while others have to be fixed by model experiments in the hydraulic laboratory which is an indispensable adjunct to proper and adequate hydraulic design.

Similarly soils and concrete Testing Laboratories are very necessary in the projects wherein the design and construction of earth and concrete dams have to be done. The collection of reliable data occupies a very important place in the works of designs. An evaluation of the basic data will be the first step in the preparation of designs. This basic data can be had only from the comprehensive reports prepared from the preliminary studies, investigations, and surveys.

The hydraulic structure should be designed for the maximum flood discharge of the river for which it is futile to depend on empirical formulae. The designer has to bear in mind the fact that the "river is a law unto itself". The blind use of empirical formulae cannot be made. The conclusions evolved from the study of one river cannot be applied to another river. Hence the maximum possible discharge of the river under consideration has to be found out.

Design of Dams

In the design of dams for impounding water the design of the spillway affects the whole design. Ample spillway capacity is of particular importance especially in the case of an earth dam. For the determination of the spillway capacity the maximum possible discharge with certain co-efficient is taken. The surplussing arrangements must be made for the floods for 1 in 100 years. The design flood is determined by the enveloped curve methods and by flood hydrographs. From the above it can be inferred that the design of spillway for letting out the flood waters is an important one. It is held to be a fundamental principle in the design of dams to provide as tight and impervious a surface as can be constructed on the face of the structure in contact with the retained water and to furnish a means of escape for such water as may pass this tight surface. This principle should govern the design of all dams. All design work must flow ahead of construction.

The height of the structure to be built depends on the maximum flood to be arrested, the area of useful land which comes under submergence, the dead storage to be provided, the power pool reserves, the fluctuations in the reservoir level for malaria control the irrigation potential to be harnessed and the water management plan. Multipurpose reservoirs should generally be larger than single purpose reservoir. In planning reservoirs for flood control, whether single purpose or multipurpose, large storage space should be provided for flood control (as much as half or more of the average annual run off on the drainage area.) In a multipurpose reservoir it should be seen that there is no encroachment on flood space. The design of a multipurpose reservoir is fundamentally an economic problem. The conflicting requirements of all the possible uses of the reservoir must be compromised. The cost of the reservoir is often equal to the cost of the dam and is therefore a major item in determining the feasibility of the project. A curve showing the relation between the height of the dam and the capacity of the reservoir formed by it will serve as a useful guide in determining the economic height. For flood

control, the reservoirs, to be of value must be comparatively near to the area which is to be protected by them. In general to give effective protection against floods the capacity of the reservoir should be such as to reduce the flood discharge at the point under consideration by at least one third. The flood control must start from upstream.

Earth Dams

The present trend is to design the earthen embankments as zonal embankment having a 'purely impervious central core enclosed by materials gradually decreasing in imperviousness and completely pervious material at the extreme end zones. This scheme helps to conserve the available materials and utilise them to the best advantage. For stability and greatest economy a high fill must have compound slopes with the steepest practicable slope in the upper reaches followed by gradually flatter slopes towards the toe separated by berms. The only consideration which this type of structure namely earth dam demands is its water tighteness, safety against seepage and overtopping, resistance to sliding and surface protection against the attack of burrowing animals and the impact of rain water. Watertightness is secured by having an impervious core in the central portion enclosed by materials gradually decreasing in imperviousness and with increassed internal friction. Seepage is taken care of by providing a thick impervious blanket on the upstream side, a cut-off trench back-filled with impervious material, sheet pile cut-off wall in the sandy river bed portion slightly upstream from the dam axis; inverted filters and toe drains on the downstream side. The over-topping is guarded against by providing sufficient length of spillway structure and an adequate free board to the embankment. The action of burrowing animals is prevented by having a thick vegetal cover on the downstream slope. The upstream slope is protected against wave action by having a thick layer of about 3′ to 4′ of rip-rap. The impact of storm water on the downstream slope is minimised by providing berms at vertical intervals of about 30 to 40 feet and having drains in the berms to carry away the rain water.

These are the general features which are to be incorporated while designing the earth dam. The slope of the section will be fixed to resist sliding after making a thorough analysis by the slip circle method for various critical conditions. The statble slopes will be taken as those which yield by this analysis a shear friction safety factor of 1.5. In this analysis the physical properties of the soil serve as the basic data and soil laboratory plays a paramount part and acts as the chief guide in the design of earth dam. The effect of rapid draw-down on the upstream slope deserves careful investigation in the design of earth dam. In checking the stability of the slope for draw-down from maximum to minimum pool level a minimum safety factor of 1.0 is very essential.

The design problem for an earth dam is to determine that cross-section which, when constructed with the materials at hand, will safely fulfil its required function at a minimum cost. The designer of an earth dam cannot, to the same degree as for a concrete or masonry structure, rely upon the application of mathematical analysis or formulae to determine its required section. It therefore becomes apparent that there is no standdard type of cross section for an earth dam. The cross section design is fundamentally controlled by (1) the nature and physical properties of the materials of construction (2) the materials composing the foundation and (3) to a certain extent by the adopted methods and rate of construction.

Finally it can be summarised that the earth dam should be designed such that (1) there is no danger of overtopping (2) the seepage line is well within the downstream face (3) the upstream face slope is safe against sudden drawdown, (4) the upstream and downstream slopes are flat enough that with the materials utilised in the embankment they will be stable, (5) there is no opporunity for the free passage of water from the upstream to the downstream face, (6) water which passes through and under the dam when it reaches the discharge surface has a pressure and velocity so small that it is incapable of moving the material of which the dam or its foundation is composed and (7) the upstream face is properly against protected wave action and the downstream face is protected against the action of the rain.

Trends in the Construction of Dams

The construction of the project is to be so programmed that benefits start accruing systematically with the completion of each phase of the project and that development is not held up for want of completion of any individual component of the project when other projects are completed. This is all the more important in the case of larger projects which are generally multipurpose in nature involving large investments of capital. Any lopsided progress in a project would result in idle capital, deferred benefits and frustrated hopes. We have to think of the most economic sequenence of building the various component structures of the projects. An orderly sequence of construction will also permit construction equipment and keymen to be passed on from one job to another, thus maintaining a high degree of skill and efficiency on works. This brings to light the importance of phasing in the river valley projects. This leads to the fact that the development of the river valleys should be a stage development. The essence of the stage development is that after the overall integrated plan has been prepared and accepted the component units can be taken up for execution in the most profitable and expeditious manner so that the benefits and revenue start acruing on one one stage simultaneously with the undertaking of the next stage. By judicious phasiug of the project it becomes possible to cover the equipment, materials and technical personnel much wider field of activity than would be otherwise.

Before the construction of a project is launched upon it is necessary to draw up a programme of construction, fix target dates for completion of the various components and to work out a programme of expenditure. A seasonwise programme of construction should be drawn up at the commencement of a project and a

detail programme for the season's work must be drawn up before the beginning of the working season. Material schedule, equipment schedule regarding placing orders and for their arrival at the site and progress schedule should be prepared before the work is started.

The diversion of the river is a very important feature in the construction of the river valley projects. Since this aspect affords greatest scope for economy in these works, attention needs to be exercised in preparing the plan for the diversion of the stream. As the biggest opportunity for economy in the river valley project rests in the development of the best scheme for handling the river, the diversion of the river out of its natural bed during the construction is the most important and most critical operation in the construction of a dam. The methods of diverting the stream depend on the topography of the site, the nature of the stream to be handled and the quantity of discharge to be diverted. Where the dam site is a deep canyon or where the configuration of the site is such that there is a high hill near one of the banks of the river, the diversion through a tunnel is the most common method. On large dam site the topography of the site is one of the controlling factors in determining the construction procedure. The method or scheme of diverting the design flood depends on the probable construction schedule and the local conditions at site as well as economy.

Equipment Planning

The extent to which the projects should absorb manual labour for relieving unemployment, which is an important policy question, should be studied. The sub-committee on equipment has laid down the rule that jobs requiring leads less than 500 feet and lifts of less than 30 feet need not be meachnised unless the progress schedules make it impossible to use manual labour.

When a decision is taken that the nature of the job calls for substantial degree of mechanisation, a definite plan has to be made for procurement and layout of the construction plant. Plant planning is very vital for securing businesslike results. Before the section of theequipment a thorough study of the job condition is imperative. A full knowledge of the materials to be excavated, the transpport conditions, the yardage of work involved enables the project man to make the best selection of the type of equipment needed. A complete plan of excavation, loading and dumping of earth work, crushing, conveying and storing of aggregates, mixing and laying of concrete should be prepared before the equipment is thought of. The equipment needed has to be streamlined for a flow line production. In deciding the equipment for the project one has to bear in mind the question of proportion of cost spent within the country for doing the work with the machinery and the amount that has to be spent outside. The size of the plant is of primary importance. Determination of the proper size depends on job conditions. It is also necessary that the standard equipment which is being manufactured in large numbers should be ordered in order to facilitate the easy availability of spare parts. The maxim "service after sale" needs to be kept in view. On a large dam site the topography of the site is one of the controlling factors which dictate the type of construction plant to be adopted. A deep gorge site may call for a cableway layout whereas a long low head dam in a flat river valley needs a construction bridge and cranes.

Materials of Construction

Materials that are employed in the construction of dams may be concrete or stone with lime or cement mortar; or earth. Earth dams are cheaper than masonry dam and are eminently suitable under some conditions where rock foundation is deep. An earth dam is the only suitable type to build upon an unconsolidated foundation of low shear value. Where the foundations at the site consist of good hard rock, where less equipment requiring foreign exchange is desired, where it is necessary to economise the use of cement, where employment opportunities for considerable manual labour are available, where unemployed or under-employed are to be provided for, and where the height of the hydraulic structure is of medium or not of great height there it is prudent to prefer stone masonry. The use of costly construction plant and the employment of foreign personnel can be avoided if the dam is to be build of stone masonry. Therefore stone masonry is suitable at places where we can do without concrete at cheaper rates. Concrete is better where we cannot get masonry. The question is of overall economy and programme. The principal factors to be considered in deciding whether a dam of any particular height or size at a particular location be constructed in stone masonry or in concrete are normally the permissible strength of the material used, the relative period of construction and the relative cost.

An adequate number of trained technical personnel is an important aspect of river valley project. Without having the technical "know-how" both for the design and construction of these huge works it will be difficult to have a good quality of the work within the planned period and estimated cost. In a mechanised construction job the periodical measurement of production has to be entrusted to an independent group of technical personnel as the men actually employed on the construction proper can find no time away from the machine operation for attending to this work. In these construction works involving highly mechanised operations, operational studies and observations of outputs must be conducted to help carrying out engineering costing and to provide data for planning similar projects in the country.

Construction of Earth Dam

The construction of an earth dam is nothing but the reworking of the excavated material with air and water by mechanical appliances to get at a water tight and safe structure. In the geo-chemical reaction which takes place during reworking, water plays a paramount part. The moisture density relationship should be found in the laboratory for this reworking of the soil since a certain degree of plasticity is required to facilitate the geo-chemical activity and attain maximum density. The stability of an earth dam is dependant

to a great extent on the moisture condition at the time of placing. The quality of the work depends on compacting the layers of materials at the optimum moisture content only. Getting this optimum moisture content througout the soil mass in the layer is the yard stick of the quality of construction. The maximum degree of compaction consolidation requires the following: (1) sufficiency of moisture (2) thorough kneading by the repeated passage of the roller and (3) adequate compaction. The embankment must be raised in compacted layers of 6" thickness.

Construction of Concrete Dam

In the case of concrete dams it is necessary to build them in blocks. The blocks are constructed by providing open joints transverse to the axis of the dam at intervals of not more than 50 feet. In order to reduce temperature cracking to a minimum, the concrete should be placed at low temperatures. Thin concrete lifts about 5 to 6 feet should be adopted with suitable time interval say about 7 days between lifts. The concrete placing schedule must be kept uniform. Lastly the concrete mass should be cooled artificially, for the interior of dams cement content as low as 280 lbs per cu. yd. is to be used. Both for economic and technical reasons there are advantages in using concrete containing as little cement as will give the properties required. The desirability of low cement and water contents for interior concrete necessitates careful control of aggregate grading and quality to obtain lean workable mixes that give adequate strength and low permeability. A dense and rich mix is recommended for the concrete in the outer portion. Due to this fact the concrete for the dam is classified into different classes depending on the cement content and the zones where it is put.

Drainage galleries should be provided in the concrete dam and also in masonry dam to reduce the uplift pressures, Operation galleries for the operation of undersluices in the dam need provision. Form drains are to be provided in the blocks to collect any seepage water through the open joints between the blocks. Vent pipes which give access to air in undersluice bell mouths and gate chambern for the easy operation of the the gate are to be built. In a nut shell the main features to be incorporated in the concrete dam are the drainage gallery to minimise the uplift pressure, the operation gallery for the operation of the undersluice gates and scouring sluice gates, form drains and vent pipes. Reinforcements should be provided alround the openings provided in the dam. Undersluices have to be provided inside the body of the dam in reduce the overflow length of the dam so that the maximum discharge to be surplussed is divided into the the flow over the crest and flow through the undersluices.

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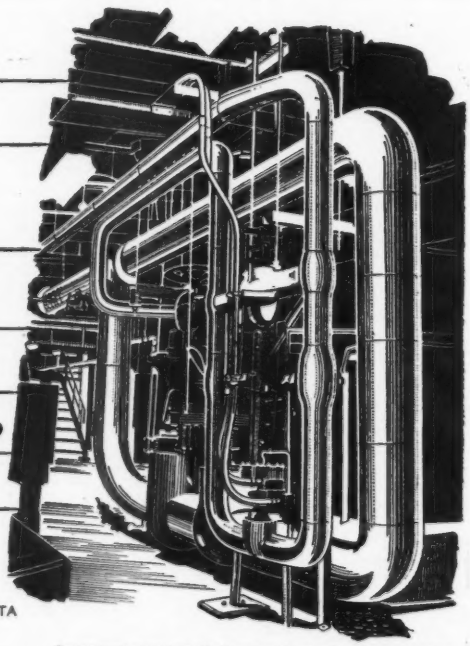


Feed pipework at the boiler feed pumps at Trombay Thermal Power Station

Technical Notes & News

Some Japanese Research

The Journal of Techinical Laboratory published by the Central Research Institute of Electrical Power Industry, Japan, in its issue Vol. 9. no.1-2 has published several interesting reports, abstracts of which are noted below :

Actual Performance of Arch Dams obtained from the observation of Kamishiiba Dam by Kimijima H. Nakaarai K.

The actual performance of the contraction joints and its effect on stresses are investigated in Kamishiiba Arch Dam by means of various kinds of embedded Carlson meters in order to verify reliability of the widely used assumption of isotropic and monolithic body in the field of concrete dams, particularly of arch dams.

Each measured result by thermometers, joint meters, stress meters and an elastic wave test agreed unanimously and testified that contraction joints, especially those in the upper part of the dam, are not always kept in contact even in the arch dam.

The investigation clarified that estimated tensile stresses in arch and cantilever almost disappeared and consequently, showing desirable effects and also that actual stresses in arch dams are extremely complicated due to state of temperature, construction method and existence of imperfect contacted joinst.

The author believes that a conception of voussoir arch is to be kept in mind in the design and construction of arch dams.

Evaporation from Reservoirs (Part 1) by Asada H. and Fukuhara K.

Field evaporation tests are under preparation in number of different ways in order to observe the loss of storage water due to surface evaporation of a reservoir.

A field observation was made on evaporation of a small pond as its first step by means of 10 floating pans with 15 cm dia. and 2 land pans with 120 cm dia.

Its one week finding resulted in a horizontal distribution through day and night evaporation under a very calm waveless condition.

Relation between Test Results of Specific Gravity, Absorption, Soundess and Abrasion of Concrete Aggregate by Nishizawa N.

At our laboratory, many tests of aggregates were made during the past five years in order to decide suitability of the aggregate for use. The testing included both petrographic analysis and physical properties tests. In this paper, however, the results of specific gravity test, absorption test, sodium sulphate soundness test and abrasion test were only analyzed. The conclusions which appear to be indicated by the analysis are as follows :

(1) The 54 samples of coarse aggregates and the 72 samples of fine aggregates, of which sources were distributed almost all over the country of Japan, had the great lithologic variety.

(2) The relationships which where observed in the analysis were as follows: The bulk specific gravity decreases as the absorption increases.

The sulphate loss and the abrasionin the Los Angeles test increase with decrease in bulk specific gravity and increase in absorption.

The abrasion increases as the sulphate loss increases.

(3) The scattering of test results obtained indicates that other factors are influencing the relationships described above.

(4) Aggregates appear to be classified on the basis of the bulk specific gravity and the absorption as Table 3. The classification seems to be practically convenient in selection of aggregates.

Basic Research on the Testing Apparatus of Draft Tube (Part 2) by Sagawa T.

A testing device was made in trial to facilitate research on a water turbine draft tube. This paper treats of findings made experimentally and theoretically on the statuses of water flow in a tail tank, a measuring channel and a cylindrical draft tube.

Principally such points are made clear in this paper as correlation between water depth and flow quantity under a steady state, influence of erroneous handicraft and installation upon a flow quantity, a desirable measurement interval of fluctuating water levels, the fluctuation of a water level due to fluctuation of a flow quantity a flow status in a cylindrical draft tube, etc.

Temperature Measurement of Power Line Joint by Means of Infra-red Detector by Shigedai G. Kimura H. Machida T. Miyazaki Y. Takagi S. Saito K. Kikuyama A.

An infrared ray locator pith a thermocouple was turn out in trial by the author and his associates in order to test, from a point apart as long a distance as several decade meters, the temperature of a power line splice which is supposed to be not higher than 200°C.

In number of field applications, remarkably better results were

achieved than expected. This report outlines how the locator operates and deals with remote measurement of a surface temperature by means of it, a comparison method in application of calibration curves and with findings of the field tests conducted recently in the regional power systems of Hokkaido, Hokuriku and Tokyo. Features and practical value of the locator are also touched on.

Post-Graduate Course in Engineering

The University of Roorkee is running the following courses of post-graduate standard for the benefit of serving engineers of the country.

Civil.

1.	Short-term course in Public Health Engineering for engineers	1st March to 31st May, 1960
2.	Special course in Foundation Engineering.	15th April to 14th May, 1960.
3.	Refresher course in Foundation Engineering, Concrete, Buildings, Highways and Bridges.	15th April to to 14th July. 1960.

Mechanical.

4.	Special course in Heavy Earthmoving Machinery.	2nd to 22nd May, 1960.

Electrical.

5.	Refresher course in Transmission and Transformation and Generation.	1st June to 31st August 1960.

Another short-term course in Public Health Engineering open to Engineering Subordinates is also being run from Ist March to 31st May, 1960. Detailed particulars may be had from the Director, Refresher Courses, University of Roorkee, Roorkee.

Indo-German Technical Co-operation in Private sector

An existing technical collaboration arrangement between two noted engineering firms has been further extended with the signing of an additional agreement recently between Bharat Bijlee Limited, Bombay—a reputed Indian firm manufacturing motors and transformers,—and Siemens Engineering & Manufacturing Company of India Private Limited—Sole Representatives of Siemens & Halske A. G. and Siemens-Schuckertwerk A. G., West Germany—the world's second largest electro-establishment, employing nearly 190,000 people.

Mr. P. C. Mehta (right) director of Bharat Bijlee Limited looks on as Mr. G. H. Swatek, Managing Director of Siemens Engineering & Manufacturing Company of India Private Limited puts his signature to the agreement. On the left is Mr. M. U. Motwane of Siemens of India.

As a result of this joint enterprise, Bharat Bijlee motors and transformers will now be progressively made in India under licence of Siemens-Schuckertwerke A.G., West Germany, and will conform to the Siemens design. With effect from January 1st 1960, all Bharat Bijlee products will be marketed and serviced by Siemens Engineering and ManufacturingCompany of India Private Limited.

Proposed Tyre Factory in India

Plans for a 12 million tyre and tube manufacturing project 20 miles south of New Delhi, India were announced by P. E. H. Leroy, vice chairman of the board of the Goodyear Tyre & Rubber Company.

The new plant, to be located on a 50-acre site on the Agra road—which leads to the Taj Mahal—is the third new plant facility outside to the United States to be announced by Goodyear within the past year. Goodyear disclosed in April that it would build a tyre manufacturing plant at Amiens, France; and in August, the erection of a tyre plant in Medicine Hat, Alberta, Canada.

"The decision to establish a plant in India," Leroy said, "demonstrates support of the growing Indian economy by American industry—action specifically recommended by President Eisenhower during his recent visit to the country.

"Improved economic conditions and standards of living in India are being accompanied by increased vehicle registrations. The new Goodyear installation will help fulfill the need for tyres these transportation advances are creating."

The new plant of the Goodyear Tyre & Rubber Company of India Ltd. will employ approximately 900 workers, virtually all Indians, and is expected to be completed early in 1961.

Leroy said the plant will be equipped with the most modern tyre manufacturing machinery for the production of passenger, truck and farm tyres and tubes.

A team of engineers from Goodyear's Akron, Ohio, headquarters is in India and construction is scheduled to begin immediately.

The Ninth Annual Meeting of the Central Board of Flood Control was held in Vigyan Bhawan, New Delhi, on December, 28, 1958, under the chairmanship of Hafiz Mohd. Ibrahim, Union Minister of Irrigation & Power. In the picture Hafiz Mohd. Ibrahim (third from the right, near the camera) can be seen addressing the Meeting.

U.S. Bank's Rupee loan for the Tyre Factory

The U. S. Export-Import Bank today announced that it had approved a credit of Rs. 2.25 crores to help build a tyre factory at New Delhi.

The loan (in Indian currency) was made to the Goodyear Tyre and Rubber Company of India, an affiliate of the U. S. firm of the same name.

The new factory would employ 900 people and produce large lorry tyres together with tyres for cars, buses and tractors, tubes, tread rubber and repair materials.

The bank said this was its largest-ever foreign currency transaction.

Indian standard for Installation A. C. Electricity meters three-phase Kilowatthour meters with maximum demand Indicator

The Indian Standards Institution has drafted an Indian Standard Specification for A.C. Three-Phase Kilowatthour Meters with maximum Demand Indicators : [Doc ETDC 6 (73)].

The energy meters covered by this standard (IS : 722-Part IV) incorporate a maximum demand indicator thus enabling the meter to record the maximum demand during the demand integrating period. This standard which gives the requirements and tests for such meters, is to be read in conjunction with IS. 722 (Part 1 and II) 1955 the first part of which covers general requirements of all types of AC whole-current electricity meters.

The draft is being circulated widely for inviting comments from concerned interests before finalizing the draft as Indian Standard.

Copies of the draft, free on request, are available from the office of the Indian Standards Institution, Manak Bhavan 9 Mathura Road, New Delhi and from its branch offices at Bombay, Calcutta and Madras.

Mr. Marty Retires

Mr. Marty, General Manager of Batliboi & Co., one of the leading engineering concerns, recently retired after long service. During his tenure, Batliboi & Co. supplied big power plants to various river valley and other projects in all parts of India and thus contributed to the success of the nation's five year plans.

Mr. Marty, General Manager, Batliboi & Co.

A farewell party was arranged in honour of Mr. Marty when Mr. Pratap Bhogilal, director of the company, eulogized Mr. Marty's services. Mr. Marty will be permanently settling in Australia.

Caterpillar No. 583 Pipelayer

A power shift transmission, featuring an exclusive new concept in the transmittal of pipelayer power, is now available on the Caterpillar No. 583 Pipelayer.

The new transmission provides instantaneous, one-lever control of gear shifting without interruption of power and momentum. It is built to withstand the demanding conditions of pipelayer service, having undergone 50,000 test hours during an extensive development program.

In addition, by a unique utilization of planetary gear versatility —introduced to the industry on these machines—pipelayer performance is provided which combines the best features of both direct drive and torque converter power trains. Heart of the new power-tailoring arrangements is a planetary gear set, driven integrally by the engine flywheel, which transmits 1/3 of the engine torque directly to the transmission input shaft, and the remainder through the torque coverter.

Horsepower of the No. 583 Pipelayer has been increased from 225 to 235, to give an additional boost to productivity.

Instant, Effortless Shifting.

On the operator's deck, one speed-range selection lever now takes the place of the three levers which formerly controlled gear selection, flywheel clutch operation and forward-reverse movement. In terms of operator efficiency, this means: reduced shifting time, effortless and simplified gear changes. Only a fraction of a second is required to actuate the power shift transmission, as against a shift time often up to several seconds for standard transmissions.

Shifting ease insures the matching of pipelayer speed and power to the terrain. With finger-tip selection of gears, the powershift transmission permits rapid movement on the pipeline right-of-way.

In the dope and wrap operation, for example, the pipelayer can instantly match its speed to the wrapping unit even under adverse conditions such as uncertain underfooting or grade changes. In the lowering-in operation, the reduced shifting time insures rapid movement in changing machine positions, increasing laying efficiency.

At the time information on the split-path transmission of engine torque was released, Caterpillar Tractor Co. underscored the inherent advantages of this precedent-setting design. By directing a portion of engine torque straight to the transmission input shaft, it provides higher overall efficiency than a standard torque converter drive and retains the solid feel of direct drive machines.

The remainder of the engine power is directed through the torque converter, allowing the tractor to automatically adjust travel speed to load, as on normal torque converter drive pipelayers.

Power Shift Transmission and Control

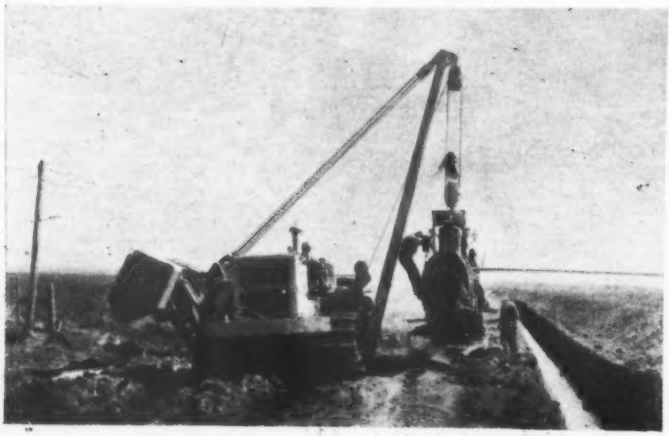
The No. 583 power shift Pipelayer has a three-speed forward, three-speed reverse, planetary transmission. It consists of five in-line gear trains, each with a separate clutch. Two of the planetary trains are directional; three constitute the low, intermediate and high gear ranges. Control of the clutches is by a direct-acting. hydraulic control system, designed and build by Caterpillar. Design of the hydraulic system is such that the speed range clutches are engaged first when shifting, followed by engagement of the forward or reverse clutches. This feature assures smooth transitions when changing speed ranges. The transmission and torque converter are connected by a universal joint, providing unit construction which premits removal of either the transmission or the torque converter without disturbing other machine components.

A safety lever is installed on the gear selector pedestal, which locks the selector lever in place when in the neutral position. The control system also contains a hydraulic safety valve, which automatically shifts the transmission into neutral when the engine is stopped.

Lubrication

Lubrication of the power shift transmission on the No. 583 Pipelayer is afforded by a separate vane-type pump located on the flywheel housing. It supplies oil through an individual filter to the transmission power clutch control unit, where it serves as hydraulic fluid for the transmission clutches. Lubricant is then channeled to the transmission bearings, gears, and clutch plates. The transmission oil sump is common with the bevel gear and steering clutch compartments.

As a part of the development program of the new Caterpillar No. 583 Pipelayer, it was tested on this pipeline in Iowa.



Editorial

The Haunting Spirit

The news of the suicide by Dr. Joseph the Indian scientist working with the Indian Council of Agricultural Research is still haunting the minds of scientists, technicians, politicians and the citizen. Suicides are not uncommon in a country with a population of 360 million. But Joseph's was rather a rude reminder of the reality that refuses to remain concealed under the the cupboard. By its very execution, it parodied the exhortation of our Prime Minister to our scientists abroad to return home spurred by a sense of patriotism. With his qualifications and experience, the learned doctor was actually receiving Rs. 60/- p.m. to maintain a large family. A sum that we will be ashamed to offer to our illiterate peons and which the latter would refuse with contempt.

* * *

The very fact that Joseph's 'spirit' is haunting us still shows that we all have a guilty conscience for his death. Can that guilt be silenced by raising a few thousands to support the bereaved family? The question that Dr. Joseph has raised by his death is one of re-examination and modernisation of the entire Scientific Policy of the country. We talk a lot about industrialisation of our country but we have yet to give proper recognition to the scientific and technical elite in the community, which is actually promoting this social transformation on such an enormous human canvas. The notion is still prevalent that it is not the scientists and the engineers but the politicians and the administrators who are the actual midwife of our industrial revolution. Let this notion die with Dr. Joseph's death, and only then a new spirit will be resurrected.

* * *

We were indeed very glad to note that after all the Aswan High Dam of Egypt has been taken up for execution. It will be remembered that in an editorial of this Journal (July, 1956) we commented that one of the factors contributing to the delay in the finalisation of the project was the "failure of the States of the Nile to reach an agreement on the division of the river waters". We are glad that since then such an agreement has been arrived at. The easing of the international tension that had flared up on the Suez issue has also taken place and increasing international financial and technical offers are now forthcoming to take up the various stages of the projects.

Indeed the High Dam will provide a great relief to the Egyptian people who are hard pressed in meeting the pressure of population that is fast growing.

It may, however, be noted here that the High Dam is comparatively a long term project in terms of benefits while Egypt needs urgent solution of its food problem. It is therefore necessary to guard against the spirit of giganticism overwhelming the immediate needs which can be satisfied only with smaller and medium-sized projects. India had made this mistake and is paying heavily for it. If the High Dam is financed by international funds, internal resources should be fully utilised in increasing agricultural production through smaller projects. There are, truly speaking, no short-cuts to industrialisation and prosperity for countries which are overwhelmingly agricultural and under-developed.

* * *

After a lapse of three years the Fourth Regional Technical Conference of the ECAFE has now been fixed to be held at Colombo in December 1960. Some of the items on the agenda appear to be most opportune. They are

1. A review of water resources development in the countires of the region from 1951 to 1960:
   Development in the fields of multiple purpose development, irrigation, flood control, hydroelectricity and navigation; important problems met with and how they were solved; appraisal of water resources of the country.

2. Organization for planning, design, construction and operation of river valley projects:
   Relative merits and suitability of various kinds of organizations, such as: autonomous and semi-autonomous corporations ; construction corporations; control boards; river commissions and development boards.

3. Development of ground water resources.
   Assessment of ground water potential; procedures and techniques employed; review and future programme of ground water resources development.

4. Flood problems in deltaic regions:
   Siltation; prevention of salt water intrusion; reclamation of salt impregnated lands.

Our Contributors

Dr. B. K. R. Prasad has been our frequent contributor.

Mr. D. C. Bhardwaj joined the Lahore Electric Supply Co. Ltd., in 1933 after graduation in Electrical Engineering with honours. In 1944 he joined the Alumunium Corporation of India and became Chief Engineer of their works in 1951. In 1951 he joined the Ahmedabad Electricity Co. Ltd., and is at present Superintendent of their Power Stations A, B. & C at Sabarmati. He contributed an interesting article on Thermal Power Stations to this journal in February 1958.

Mr. B. K. Banerjee graduated from Bengal Engineering College, Sibpore, and obtained first class. After an initial period with the English Electric Co. Ltd., and Andrew Yule & Co. Ltd., joined Electricity Development Directorate, Government of West Bengal in 1950. Now Divisional Engineer in charge of Commercial Division, West Bengal State Electricity Board. Toured United Kingdom and the Continent under the Colombo Plan in 1957-58 for about six months and had specialised training in the East Midlands Electricity Board, U. K. in tariff, load survey, load development and other commercial matters.

Mr. Rene Marie Leon Langlois is graduate in Letters and Science and an Engineer. He is Assistant Equipment Director, Head of the French Electricity Board (Electricite de France), Project and Survey Department.

His career has been entirely devoted to the Electricity Distribution and Transport Production Industry. He has been Chief Engineer of the nationalised "Societe des Forces Motrices de la Vienne" since April 1946. Also Assistant Director of the Hydraulic Production Department until 1955. As such he joined, at the end of 1951, the A. F. A. P. & ECA Productivity Mission.

On the occasion of the 6th Big Dam Congress held in New York in September 1958 he made a tour to the hydro-electric works of Eastern Canada and Western U.S.A.

Mr. Leo Walter has contributed in our journal previously.

Mr. V. Rama Rao B.Sc., B.E. is Executive Engineer DVC., Maithon. He was the Editor of the Bulletin of the Technical Club, DVC., Maithon. He has contributed a number of articles dealing with various problems in River Valley Projects.

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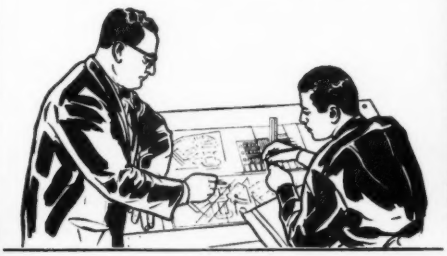

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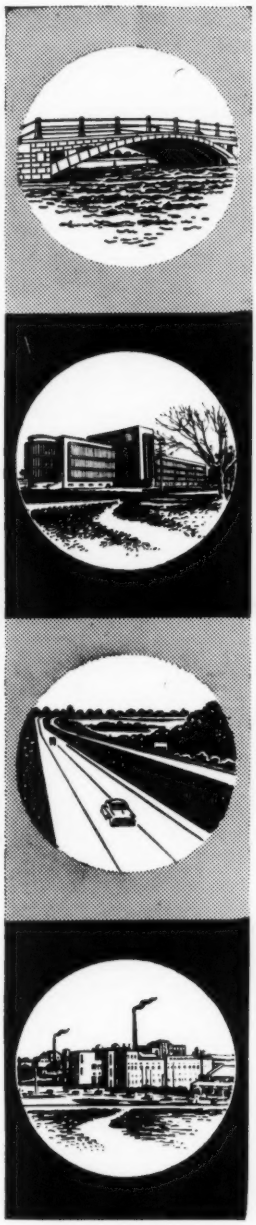

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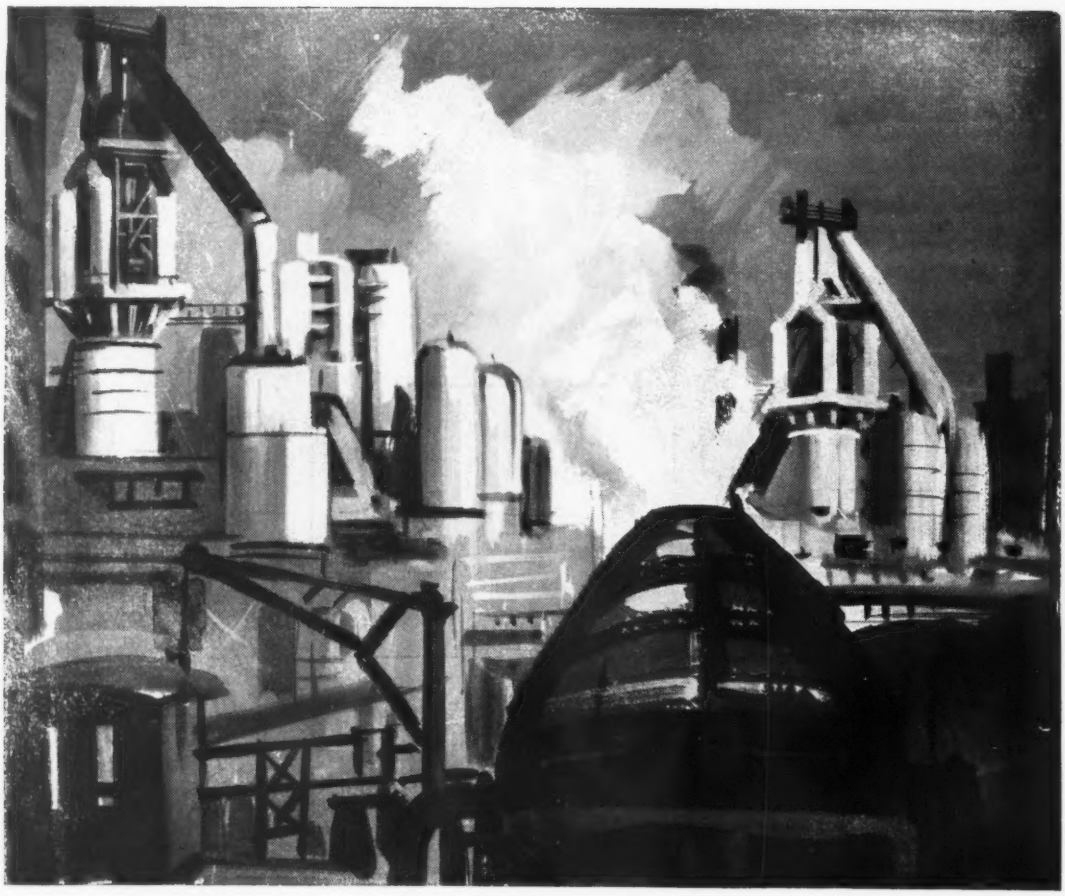

Bessemer Converter and new Blast Furnaces at the Burnpur works of The Indian Iron & Steel Company Limited

This is the heart of a giant industry. Here converges an endless stream of raw materials—coke, limestone and iron ore to feed the roaring blast furnaces. Here blows the Bessemer converter with its charge of molten metal, engines drawing ladles come and go, cranes clank and swing, men toil and sweat, here begins the ordeal by fire—the first step in the making and shaping of Steel.

IIC-72